

NOTICE

All drawings located at the end of the document.

DRAFT FINAL

PHASE I RFI/RI WORK PLAN

**ROCKY FLATS PLANT
SOLAR EVAPORATION PONDS
(OPERABLE UNIT NO. 4)**

**U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado**

ENVIRONMENTAL RESTORATION PROGRAM

NOVEMBER 1991

Volume I -- Text

ADMIN RECORD

REVIEWED FOR CLASSIFICATION/UCM
By *[Signature]*
Date 11/21/91
A-DU04-000095

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TABLE OF CONTENTS

	<u>PAGE</u>
LIST OF TABLES	viii
LIST OF FIGURES	x
LIST OF PHOTOGRAPHS	xiii
LIST OF ACRONYMS	xiv
EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION	1-1
1.1 ENVIRONMENTAL RESTORATION PROGRAM	1-2
1.2 WORK PLAN OVERVIEW	1-2
1.3 REGIONAL AND PLANT SITE BACKGROUND INFORMATION	1-3
1.3.1 Facility Background and Plant Operations	1-3
1.3.2 Previous Investigations	1-4
1.3.3 Physical Setting	1-5
1.3.3.1 Location	1-5
1.3.3.2 Topography	1-6
1.3.3.3 Meteorology	1-6
1.3.3.4 Surface Water Hydrology	1-7
1.3.3.5 Ecology	1-8
1.3.3.6 Surrounding Land Use and Population Density	1-9
1.3.3.7 Regional Geology	1-10
1.3.3.8 Hydrogeology	1-13
2.0 SITE CHARACTERIZATION	2-1
2.1 REGULATORY HISTORY OF OU4 AND INTERIM RESPONSE ACTIONS	2-1
2.2 BACKGROUND AND PHYSICAL SETTING OF OU4	2-2
2.2.1 The Original Pond	2-3
2.2.2 Solar Evaporation Pond 207-A	2-4
2.2.3 Solar Evaporation Ponds 207-B North, Center, and South	2-5
2.2.4 Solar Evaporation Pond 207-C	2-6
2.2.5 Trenches and Sumps	2-6
2.2.6 Interceptor Trench System	2-7
2.3 PREVIOUS INVESTIGATIONS	2-8
2.4 SITE GEOLOGY AND HYDROLOGY	2-11
2.4.1 Site Geology	2-11

TABLE OF CONTENTS (continued)

	<u>PAGE</u>
2.4.1.1 Surface Geology	2-12
2.4.1.2 Bedrock Geology	2-14
2.4.2 Hydrology	2-17
2.4.2.1 Ground Water	2-17
2.4.2.2 Surface Water	2-19
2.5 NATURE OF CONTAMINATION	2-20
2.5.1 Sources -- Solar Evaporation Ponds	2-21
2.5.1.1 Pond 207-A	2-22
2.5.1.2 Ponds 207-B North, Center, and South	2-23
2.5.1.3 Pond 207-C	2-24
2.5.1.4 Contaminant Behavior	2-25
2.5.1.5 Other Sources	2-27
2.5.2 Soils	2-27
2.5.3 Ground Water	2-36
2.5.3.1 Alluvial Ground Water Quality	2-37
2.5.3.2 Bedrock Ground Water Quality	2-37
2.5.4 Surface Water Quality	2-38
2.5.5 Air	2-39
2.6 SITE CONCEPTUAL MODEL	2-40
2.6.1 Pond Liquids and Sludges	2-41
2.6.2 Surficial Soils	2-41
2.6.3 Vadose Zone	2-41
2.6.4 Unconfined Ground Water System	2-42
2.6.5 Surface Water and Sediments	2-43
2.6.6 Air	2-43
2.6.7 Biota	2-44
2.6.8 Receptors and Pathways	2-44
3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS	3-1
3.1 THE ARAR BASIS	3-1
3.2 THE ARAR PROCESS	3-1
3.2.1 ARARs	3-3

TABLE OF CONTENTS (continued)

	<u>PAGE</u>
3.2.2 TBCs	3-3
3.2.3 ARAR Categories	3-3
3.2.4 Remedial Action	3-4
4.0 DATA NEEDS AND DATA QUALITY OBJECTIVES	4-1
4.1 STAGE 1 - IDENTIFY DECISION TYPES	4-2
4.1.1 Identify and Involve Data Users	4-2
4.1.2 Evaluate Available Data	4-3
4.1.2.1 Quality and Usability of Analytical Data	4-3
4.1.2.2 Physical Setting	4-4
4.1.2.3 Characterization of Contamination of the Solar Ponds	4-4
4.1.3 Develop Conceptual Model	4-4
4.1.4 Specify Phase I RFI/RI Objectives and Data Needs	4-5
4.2 STAGE 2 - IDENTIFY DATA USES/NEEDS	4-6
4.2.1 Identify Data Uses	4-6
4.2.2 Identify Data Types	4-7
4.2.3 Identify Data Quality Needs	4-7
4.2.4 Identify Data Quantity Needs	4-8
4.2.5 Evaluate Sampling/Analysis Options	4-8
4.2.6 Review of PARCC Parameter Information	4-9
4.3 STAGE 3 - DESIGN DATA COLLECTION PROGRAM	4-10
5.0 RCRA FACILITY INVESTIGATION/REMEDIAL INVESTIGATION TASKS	5-1
5.1 TASK 1 - PROJECT PLANNING	5-1
5.2 TASK 2 - COMMUNITY RELATIONS	5-2
5.3 TASK 3 - FIELD INVESTIGATION	5-2
5.3.1 Upgradient Ground Water Monitor Well Installation	5-3
5.3.2 Site-Wide Radiological Survey and Surficial Sampling Program	5-3
5.3.3 Vadose Zone Monitoring	5-3
5.3.4 Original Pond Investigation	5-3
5.3.5 Solar Ponds Area	5-4
5.3.6 Interceptor Trench System and Remainder of Site	5-4
5.4 TASK 4 - SAMPLE ANALYSIS AND DATA VALIDATION	5-5

TABLE OF CONTENTS (continued)

	<u>PAGE</u>
5.5 TASK 5 - DATA EVALUATION	5-5
5.5.1 Site Characterization	5-6
5.5.2 Source and Soils Characterization	5-6
5.6 TASK 6 - PHASE I BASELINE RISK ASSESSMENT	5-6
5.7 TASK 7 - DEVELOPMENT, SCREENING, AND DETAILED ANALYSIS OF REME- DIAL ALTERNATIVES	5-7
5.7.1 Remedial Alternatives Development and Screening	5-7
5.7.2 Detailed Analysis of Remedial Alternatives	5-10
5.8 TASK 8 - TREATABILITY STUDIES/PILOT TESTING	5-11
5.9 TASK 9 - PHASE I RFI/RI REPORT	5-11
6.0 SCHEDULE	6-1
7.0 FIELD SAMPLING PLAN	7-1
7.1 OU4 PHASE I RFI/RI OBJECTIVES	7-2
7.2 BACKGROUND AND FIELD SAMPLING PLAN RATIONALE	7-3
7.3 FIELD SAMPLING PLAN DESIGN	7-6
7.3.1 Upgradient Ground Water Monitoring Well Installation	7-7
7.3.2 Site-Wide Radiological Survey and Surficial Sampling Program	7-8
7.3.3 Site-Wide Vadose Zone Monitoring	7-10
7.3.4 Original Pond Area	7-10
7.3.4.1 Geophysical Investigation	7-10
7.3.4.2 Unconsolidated Materials Investigation	7-13
7.3.5 Existing Solar Ponds Area	7-14
7.3.5.1 Visual Inspection	7-15
7.3.5.2 Geophysical Investigation	7-15
7.3.5.3 Unconsolidated Material Investigation	7-16
7.3.6 Interceptor Trench System and Remainder of Site	7-17
7.3.6.1 Unconsolidated Materials Investigation	7-17
7.3.6.2 Piezometer Installation	7-18
7.4 SAMPLE ANALYSIS	7-18
7.4.1 Sample Designation	7-18
7.4.2 Analytical Requirements	7-19

TABLE OF CONTENTS

(continued)

	<u>PAGE</u>
7.4.3 Sample Containers and Preservation	7-20
7.4.4 Sample Handling and Documentation	7-20
7.5 DATA MANAGEMENT AND REPORTING REQUIREMENTS	7-21
7.6 FIELD QC PROCEDURES	7-21
7.7 AIR MONITORING SURVEILLANCE ACTIVITIES	7-22
8.0 HUMAN HEALTH RISK ASSESSMENT PLAN	8-1
8.1 OVERVIEW	8-1
8.2 DATA COLLECTION/EVALUATION	8-2
8.2.1 Data Collection	8-3
8.2.2 Data Evaluation	8-3
8.2.3 Hazard Identification	8-4
8.2.4 Uncertainty in Data Collection Evaluation	8-6
8.3 EXPOSURE ASSESSMENT	8-7
8.3.1 Conceptual Site Model	8-7
8.3.2 Contaminant Fate and Transport	8-8
8.3.3 Exposure Pathways	8-8
8.3.4 Potential Receptors	8-8
8.3.5 Exposure Point Concentrations	8-9
8.3.6 Contaminant Intake Estimation	8-10
8.3.7 Uncertainty in the Exposure Assessment	8-11
8.4 TOXICITY ASSESSMENT	8-12
8.4.1 Uncertainty In Toxicity Assessment	8-13
8.5 RISK CHARACTERIZATION	8-13
8.5.1 Uncertainties in the Risk Characterization	8-14
9.0 ENVIRONMENTAL EVALUATION	9-1
9.1 INTRODUCTION	9-1
9.1.1 Approach and Scope	9-2
9.1.2 Contamination Summary	9-7
9.1.2.1 Approach to Identification of Contaminants of Concern in the EE ...	9-8
9.1.3 Terrestrial and Aquatic Ecosystems and Habitats	9-9
9.1.3.1 Types, Condition, and Extent	9-9

TABLE OF CONTENTS (continued)

	<u>PAGE</u>
9.1.3.2 Biotic Taxa	9-10
9.1.3.3 Protected Species and Habitats	9-11
9.2 ENVIRONMENTAL EVALUATION TASKS	9-12
9.2.1 Task 1: Preliminary Planning and Conceptual Model Development	9-12
9.2.1.1 Coordination with RFI/RI Work and Other Operable Units	9-12
9.2.1.2 Define Scope and Study Area	9-12
9.2.1.3 Data Quality Objectives	9-13
9.2.1.4 Selection Criteria for Contaminants of Concern, Target Analytes and Taxa, and Reference Areas	9-13
9.2.1.5 Develop Conceptual Models and Food Web Analysis	9-15
9.2.2 Task 2: Data Collection and Evaluation, Preliminary Risk Assessment	9-16
9.2.2.1 Collect and Evaluate Existing Site Data and Information	9-17
9.2.2.2 Ecological Site Characterization	9-18
9.2.2.3 Preliminary Ecological Risk Assessment	9-19
9.2.2.4 Preliminary Identification of COCs, Target Species, Reference Areas	9-19
9.2.2.5 Field Sampling Approach/Design	9-21
9.2.3 Task 3: Ecological Field Investigation	9-21
9.2.3.1 Site Characterization Program	9-21
9.2.3.2 Field Investigations for Terrestrial Ecosystems	9-23
9.2.4 Contamination Impact Assessment (Tasks 4 through 7)	9-25
9.2.4.1 Task 4: Toxicity Assessment	9-25
9.2.4.2 Task 5: Exposure Assessment and Pathways Model	9-26
9.2.4.3 Task 6: Preliminary Contamination Risk Characterization	9-28
9.2.4.4 Task 7: Uncertainty Analysis	9-29
9.2.5 Task 8: Final Planning for Field Investigation	9-30
9.2.6 Task 9: Ecotoxicological Investigations	9-32
9.2.7 Task 10: Environmental Evaluation Report	9-32
9.2.7.1 Perform Final Contaminant Risk Assessment	9-33
9.2.7.2 Remediation Criteria	9-33
9.3 FIELD SAMPLING PLAN	9-34
9.3.1 Site Description	9-34

TABLE OF CONTENTS
(continued)

	<u>PAGE</u>
9.3.1.1 Study Site Detail	9-35
9.3.1.2 Reference Site Detail	9-35
9.3.2 Objectives	9-36
9.3.3 Habitat and Taxa Specific Sampling	9-37
9.3.3.1 Terrestrial Sampling	9-37
9.4 SCHEDULE	9-42
10.0 QUALITY ASSURANCE ADDENDUM	10-1
11.0 STANDARD OPERATING PROCEDURES AND ADDENDA	11-1
12.0 REFERENCES	12-1

APPENDIX A -- ENGINEERING AND CONSTRUCTION DRAWINGS

APPENDIX B -- SUBSURFACE GEOLOGIC DATA SOLAR PONDS AREA

APPENDIX C -- GROUND WATER LEVEL DATA SOLAR PONDS AREA

APPENDIX D -- SOLAR EVAPORATION POND LIQUID AND SLUDGE ANALYTICAL
RESULTS

APPENDIX E -- SOIL ANALYTICAL RESULTS SOLAR PONDS AREA

APPENDIX F -- GROUND WATER ANALYTICAL RESULTS SOLAR PONDS AREA

APPENDIX G -- AIR MONITORING DATA ROCKY FLATS PLANT

LIST OF TABLES

<u>TABLE</u>	<u>TITLE</u>
2.1	COMPARISON OF HYDRAULIC PROPERTIES
2.2	FIRST QUARTER 1990 WATER LEVELS IN SURFICIAL MATERIAL
2.3	THIRD QUARTER 1990 WATER LEVELS IN SURFICIAL MATERIAL
2.4	SOLAR EVAPORATION PONDS CONSTRUCTION DETAILS FOR MONITORING WELLS
2.5	FIRST QUARTER 1990 WATER LEVELS IN WEATHERED BEDROCK
2.6	THIRD QUARTER 1990 WATER LEVELS IN WEATHERED BEDROCK
2.7	SOLAR EVAPORATION POND 207-A SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS
2.8	SOLAR EVAPORATION POND 207-B NORTH SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS
2.9	SOLAR EVAPORATION POND 207-B CENTER SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS
2.10	SOLAR EVAPORATION POND 207-B SOUTH SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS
2.11	SOLAR EVAPORATION POND 207-C SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS
2.12	1989 SOIL SAMPLE PARAMETERS LIST
2.13	SUMMARY OF 1989 SOIL SAMPLING RESULTS FOR SELECTED METALS AND INORGANICS -- RANGE OF DETECTION (ug/g)
2.14	SUMMARY OF 1989 SOIL SAMPLING RESULTS FOR RADIONUCLIDES -- RANGE OF DETECTION PLUS COUNTING ERROR (pCi/g)
2.15	SUMMARY OF HISTORICAL SOIL SAMPLING RESULTS FOR RADIONUCLIDES RANGE OF DETECTION PLUS COUNTING ERROR (pCi/g)
3.1	POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCS, GROUNDWATER QUALITY STANDARDS
3.2	POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCS, FEDERAL SURFACE WATER QUALITY STANDARDS

LIST OF TABLES
(continued)

<u>TABLE</u>	<u>TITLE</u>
3.3	POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCS, STATE SURFACE WATER QUALITY STANDARDS
4.1	PHASE I RFI/RI DATA QUALITY OBJECTIVES FOR OU4
5.1	GENERAL RESPONSE ACTIONS, TYPICAL ASSOCIATED REMEDIAL TECHNOLOGIES, AND EVALUATION
5.2	RESPONSE ACTIONS, REMEDIAL TECHNOLOGIES, AND DATA REQUIREMENTS
7.1	PHASE I SOIL AND WATER SAMPLING PARAMETERS AND DETECTION LIMITS
7.2	SAMPLE CONTAINERS, SAMPLE PRESERVATION AND SAMPLE HOLDING TIMES FOR WATER SAMPLES
7.3	SAMPLE CONTAINERS, SAMPLE PRESERVATION AND SAMPLE HOLDING TIMES FOR SOIL SAMPLES
7.4	FIELD QC SAMPLE FREQUENCY
8.1	EPA GUIDANCE DOCUMENTS WHICH MAY BE USED IN THE RISK ASSESSMENT TASK
9.1	SUMMARY OF POTENTIAL METAL AND INORGANIC CONTAMINATION OF SOLAR EVAPORATION PONDS
9.2	SUMMARY OF POTENTIAL RADIONUCLIDE CONCENTRATION OF SOLAR EVAPORATION PONDS
9.3	SUMMARY OF POTENTIAL ORGANIC CONTAMINATION OF SOLAR EVAPORATION PONDS
9.4	PRELIMINARY LIST OF CONTAMINANTS OF CONCERN FOR OU4 ENVIRONMENTAL EVALUATION
9.5	OU4 CONTAMINANTS OF CONCERN SELECTION MATRIX
9.6	POTENTIAL TARGET TAXA FOR ASSESSMENT OF ECOLOGICAL IMPACTS AT OU4
9.7	PROPOSED ENVIRONMENTAL EVALUATION REPORT OUTLINE, SEP OU4

LIST OF FIGURES

<u>FIGURE</u>	<u>TITLE</u>
1-1	ROCKY FLATS LOCATION MAP
1-2	ROCKY FLATS PLANT AND VICINITY SURFACE WATER DRAINAGES
1-3	1989 POPULATIONS AND (HOUSEHOLDS), SECTORS 1-5
1-4	2000 POPULATIONS AND (HOUSEHOLDS), SECTORS 1-5
1-5	2010 POPULATIONS AND (HOUSEHOLDS), SECTORS 1-5
1-6	EROSIONAL SURFACES AND ALLUVIAL DEPOSITS EAST OF THE FRONT RANGE, COLORADO
1-7	ROCKY FLATS PLANT SITE-SPECIFIC STRATIGRAPHIC SECTION
2-1	OU4 AND IHSS 101 BOUNDARY
2-2	MAJOR FEATURES IN THE SOLAR EVAPORATION POND AREA
2-3	SUMMARY OF MAJOR EVENTS AT THE SOLAR EVAPORATION PONDS
2-4	POND 207-A PLAN AND SECTION DETAILS
2-5	POND 207-A NOVEMBER 1963 RELINING DETAILS
2-6	POND 207-B (NORTH, CENTER, SOUTH) PLAN AND SECTIONS
2-7	POND 207-C PLAN AND DETAILS
2-8	TYPICAL TRENCH AND ITS (FRENCH DRAIN) CROSS-SECTIONS
2-9	LOCATION MAP GEOLOGIC CROSS SECTIONS A-A', B-B', C-C' AND D-D'
2-10	GEOLOGIC CROSS SECTION A-A'
2-11	GEOLOGIC CROSS SECTION B-B'
2-12	GEOLOGIC CROSS SECTION C-C'
2-13	GEOLOGIC CROSS SECTION D-D'
2-14	BEDROCK GEOLOGY
2-15	WELL LOCATIONS IN THE SOLAR EVAPORATION POND AREA

LIST OF FIGURES
(continued)

<u>FIGURE</u>	<u>TITLE</u>
2-16	POTENTIOMETRIC SURFACE IN SURFICIAL MATERIALS, FIRST QUARTER 1990 (FEBRUARY TO MARCH)
2-17	POTENTIOMETRIC SURFACE IN SURFICIAL MATERIALS, THIRD QUARTER 1990 (AUGUST)
2-18	HYDROGRAPH -- ALLUVIAL WELLS 2686, 2886, 3086
2-19	POTENTIOMETRIC SURFACE IN WEATHERED BEDROCK, FIRST QUARTER 1990 (FEBRUARY TO MARCH)
2-20	POTENTIOMETRIC SURFACE IN WEATHERED BEDROCK, THIRD QUARTER 1990 (AUGUST)
2-21	HYDROGRAPH -- BEDROCK WELLS 2786, B208189, P208889
2-22	TOPOGRAPHIC MAP OF SOLAR EVAPORATION POND AREA
2-23	SOIL BORING LOCATIONS
2-24	NITRATE/NITRITE CONCENTRATION RANGES IN 1989 SOIL BORINGS
2-25	NITRATE/NITRITE CONCENTRATION RANGES IN HISTORICAL SOIL PROGRAMS
2-26	GROUND WATER NITRATE/NITRITE CONCENTRATION ISOPLETHS IN SURFICIAL MATERIALS, FIRST QUARTER 1990
2-27	GROUND WATER NITRATE/NITRITE CONCENTRATION ISOPLETHS IN WEATHERED BEDROCK, FIRST QUARTER 1990
2-28	SURFACE WATER MONITORING LOCATIONS INDICATING CONCENTRATIONS OF SELECTED PARAMETERS
2-29	SURFACE WATER MONITORING LOCATIONS INDICATING CONCENTRATIONS OF SELECTED VOCs
2-30	CONCEPTUAL MODEL FLOW CHART FOR OU4
2-31	POTENTIAL INTERRELATIONSHIPS BETWEEN SOLAR EVAPORATION PONDS, SOIL/VAPOR ZONE AND GROUNDWATER SYSTEM
6-1	SCHEDULE FOR PHASE I RFI/RI FOR OU4
7-1	PROPOSED UPGRADIENT MONITORING WELL LOCATION MAP

LIST OF FIGURES
(continued)

<u>FIGURE</u>	<u>TITLE</u>
7-2	RADIOLOGICAL SURVEY AND SURFICIAL SOIL SAMPLING PROGRAM
7-3	FIELD SAMPLING AND GEOPHYSICAL INVESTIGATION IN ORIGINAL SOLAR POND AREA
7-4	FIELD SAMPLING AND GEOPHYSICAL INVESTIGATION OF EXISTING SOLAR EVAPORATION PONDS
7-5	FIELD SAMPLING AND GEOPHYSICAL INVESTIGATION OF FRENCH DRAIN AND REMAINING AREAS
9-1	FLOW DIAGRAM: INTERRELATIONSHIP BETWEEN TASKS IN ENVIRONMENTAL EVALUATION
9-2	HABITATS WITHIN THE OU4 AREA
9-3	DECISION PROCESS FOR THE INVESTIGATION OF INDIVIDUAL, POPULATION AND ECOSYSTEM LEVEL EFFECTS AND FOR THE USE OF REFERENCE AREAS FOR COC EFFECTS
9-4	DECISION PROCESS FOR CHEMICAL SAMPLING OF TISSUES OR EFFECTS IN TARGET TAXA
9-5	DECISION PROCESS ON USE OF REFERENCE AREAS FOR CONTAMINANTS IN TISSUE
9-6	BIOTA SAMPLING LOCATIONS FOR OU4 ENVIRONMENTAL EVALUATION
9-7	ENVIRONMENTAL EVALUATION ACTIVITY SCHEDULE FOR OU4

LIST OF PHOTOGRAPHS

<u>PHOTO</u>	<u>DESCRIPTION</u>
2-1	SOLAR EVAPORATION POND AREA FACING SOUTH (JUNE 1991)
2-2	SOLAR EVAPORATION POND AREA FACING SOUTHWEST (JUNE 1991)
2-3	EASTERLY VIEW OF ORIGINAL PONDS WITHIN POND 207-A IN BACKGROUND (SEPTEMBER 1956)
2-4	POND 207-A ORIGINAL CONSTRUCTION OF ASPHALT PLANKING (MAY 1956)
2-5	POND 207-A AND PONDS 207-B (NORTH, CENTER, SOUTH) FACING SOUTH (JUNE 1991)
2-6	POND 207-A AND POND 207-C FACING SOUTH (JUNE 1991)

LIST OF ACRONYMS

AEC	Atomic Energy Commission
AIP	Agreements in Principle
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Ambient Water Quality Criteria
BCF	bioconcentration factor
BNA	base neutral extractables
BRA	Baseline Risk Assessment
CAA	Clean Air Act
CAD	Corrective Action Decision
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CDOW	Colorado Department of Wildlife
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMS	Corrective Measures Study
COC	contaminants of concern
CRP	Community Relations Plan
CWA	Clean Water Act
CWQCC	Colorado Water Quality Control Commission
DMC	derived media concentrations
DOE	U.S. Department of Energy
DRCOG	Denver Regional Council of Governments
DQO	data quality objective
EE	Environmental Evaluation
EER	Environmental Evaluation Report
EEWP	Environmental Evaluation Work Plan
Eh	oxidation reduction potential
EIS	Environmental Impact Statement
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ERDA	Energy Research and Development Administration
F	Fahrenheit
FIDLER	Field Instrument for Detection of Low-Energy Radiation
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FS	feasibility study
FSP	Field Sampling Plan
GC	gas chromatograph
GPR	ground-penetrating radar
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HSL	Hazardous Substance List
HSP	Health and Safety Plan
IAG	Interagency Agreement
IHSS	Individual Hazardous Substance Site

IM	Interim Measure
IPPCD	Interim Plan for Prevention of Contaminant Dispersion
IRA	Interim Remedial Action
IRIS	Integrated Risk Information System
ITPH	Interceptor Trench Pump House
ITS	Interceptor Trench System
MATC	maximum allowable tissue concentration
MDL	Minimum detection limit
MCL	maximum contaminant level
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
OPWL	Original Process Waste Lines
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PA	Protected Area
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
PCN	Procedure Change Notice
PID	photoionization detector
PQL	Practical Quantitation Limit
PRP	potentially responsible parties
QAA	Quality Assurance Addendum
QA/QC	quality assurance/quality control
QAPjP	Quality Assurance Project Plan
RAAMP	Radiological Ambient Air Monitoring Program
RAGS-EEM	Risk Assessment Guidance for Superfund-Environmental Evaluation Manual
RAS	Routine Analytical Service
RCRA	Resource Conservation and Recovery Act
RfD	risk reference dose
RFEDS	Rocky Flats Environmental Database System
RFI	RCRA Facility Investigation
RFP	Rocky Flats Plant
RI	remedial investigation (CERCLA)
RME	reasonable maximum exposure
RO	Reverse Osmosis
ROD	Record of Decision
RSP	respirable suspended particulate
SAS	Special Analytical Services
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SEAM	Superfund Exposure Assessment Manual
SEP	Solar Evaporation Ponds
SOP	Standard Operating Procedure
SPHEM	Superfund Public Health Evaluation Manual
SSH&SP	Site Specific Health and Safety Plan
SWCS	Surface Water Control System
SWMU	Solid Waste Management Unit
TAL	Target Analyte List

TBC	To Be Considered
TCL	Target Compound List
TDS	total dissolved solids
THM	Total trihalomethanes
TIC	tentatively identified compound
TOC	total organic carbon
TSCA	Toxic Substances Control Act
USCS	United Soil Classification System
UV	ultraviolet
VOA	volatile organic analysis
VOC	volatile organic compound
WQCC	Water Quality Control Commission

EXECUTIVE SUMMARY

This document presents the Work Plan for the Phase I Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI)/Remedial Investigation (RI) for Operable Unit No. 4 (OU4) at the Rocky Flats Plant in Jefferson County, Colorado.

The RFI/RI investigation is pursuant to an Interagency Agreement (IAG) among the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the State of Colorado Department of Health (CDH) dated January 22, 1991 (U.S. DOE, 1991a). The IAG program developed by DOE, EPA, and CDH addresses RCRA and CERCLA issues. Although the IAG requires general compliance with both RCRA and CERCLA, RCRA regulations apply to remedial investigations at OU4.

As required by the IAG, this Phase I Work Plan addresses characterization of source materials and soils at OU4. A subsequent Phase II RFI/RI will investigate the nature and extent of surface water, ground water, and air contamination and evaluate potential contaminant migration pathways. This Phase I Work Plan addresses characterization of source materials and soil, including (1) surficial soils, (2) unconsolidated materials, and (3) the Interceptor Trench (french drain) System. Pond liner materials will be characterized for their effectiveness as a barrier for contaminant migration.

The initial step in development of the OU4 Work Plan was a review of existing information. Available historical and background data were collected through a literature search and a review of the Rocky Flats Environmental Database System (RFEDS). This information was used in characterizing the physical setting and contamination at OU4 and in developing a conceptual model of the site.

Based on this characterization of OU4, data quality objectives (DQOs) have been developed for the Phase I RFI/RI. DQOs are qualitative and quantitative statements that describe the quality and quantity of data required by the RFI/RI. Through application of the DQO process, site-specific RFI/RI goals are established and data needs are identified for achieving these goals.

In accordance with the IAG, the goals identified for the Phase I RFI/RI for OU4 include characterization of the physical features of the sources at the site and definition of the contaminant sources within OU4.

Within these two broad goals, site-specific objectives and data needs have been identified for the Phase I RFI/RI for OU4. The Field Sampling Plan (FSP) presented in this Work Plan is designed to generate the data needed to meet the site-specific objectives. Based on the amount and reliability of existing information, the sampling/analysis activities specified in the FSP for each area of concern within OU4 require a combination of some or all of the following: screening activities, surficial soil sampling, unconsolidated materials sampling, and monitoring well installation. Site-specific sampling activities are briefly summarized below.

Field sampling activities proposed for OU4 are phased and include nonintrusive surface surveys, vadose zone monitoring, and geophysical investigations followed by intrusive borehole construction and sample collection for laboratory analysis. The results of each phase of the program will be used to assess proposed approaches and to redirect investigations, if necessary, to effectively and economically achieve the program objectives. The FSP was developed by location within the Solar Ponds area, to allow flexibility and coordination between this Phase I RFI/RI investigation and the pond liquid and sludge removal activities.

The field sampling plan includes a site-wide surface-radiation survey, a vadose zone monitoring program and a surficial soil sampling and analysis program. Results from these investigations will provide the basis for assessing dispersion of contaminants from the ponds in the form of aerosols, ground water seeps to the surface, or other mechanisms. Geophysical investigations include ground penetrating radar to delineate the Original Pond and locate subsurface piping or other features. Methods to investigate unconsolidated materials include borehole construction, sample collection and analysis, and downhole geophysics.

Limited studies are also proposed to evaluate the hydrologic characteristics of the ITS, including piezometer installation and possibly tracer studies. Borehole construction and unconsolidated material sampling are also proposed at the ITS and in outlying locations within the Solar Ponds area.

Data collected during the Phase I OU4 RFI/RI will be incorporated into the existing RFEDS data base. These data will be used to (1) better define site characteristics and source characteristics, (2) to support the baseline risk assessment, and (3) evaluate potential remedial alternatives. An RFI/RI report will be prepared to summarize the data obtained during the Phase I program. This report will also include the Phase I Human Health Risk Assessment and Environmental Evaluation.

1.0 INTRODUCTION

This document presents the Work Plan for the Phase I Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI)/Remedial Investigation (RI) for Operable Unit No. 4 (OU4) at the Rocky Flats Plant (RFP) in Jefferson County, Colorado.

This investigation is part of a comprehensive, phased program of site characterization, remedial investigations, feasibility studies, and remedial/corrective actions currently in progress at RFP. These investigations are pursuant to an Interagency Agreement (IAG) among the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the State of Colorado Department of Health (CDH) dated January 22, 1991 (U.S. DOE, 1991a). The IAG program developed by DOE, EPA, and CDH addresses RCRA and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) issues. Although the IAG requires general compliance with both RCRA and CERCLA, RCRA regulations apply to remedial investigations at OU4. In accordance with the IAG, the CERCLA terms "Remedial Investigation" and "Feasibility Study" as used in this document are considered equivalent to the RCRA terms "RCRA Facility Investigation" and "Corrective Measures Study" (CMS), respectively. Also in accordance with the IAG, the term "Individual Hazardous Substance Site" (IHSS) is equivalent to the term "Solid Waste Management Unit" (SWMU).

As required by the IAG, this Phase I Work Plan addresses characterization of source materials and soils at OU4. A subsequent Phase II RFI/RI will investigate the nature and extent of surface water, ground water, and air contamination and evaluate potential contaminant migration pathways. This Phase I work plan addresses characterization of source materials and soil, including (1) surficial soils, (2) vadose zone materials, and (3) the Interceptor Trench (French Drain) System. Pond liner materials will be characterized for their effectiveness as a barrier for contaminant migration.

In this Work Plan, the existing information is summarized to characterize OU4, data gaps are identified, data quality objectives (DQOs) are established, and a Field Sampling Plan (FSP) is presented to characterize site physical features and define contaminant sources.

The Phase I RFI/RI will be conducted in accordance with the *Interim Final RCRA Facility Investigation (RFI) Guidance* (U.S. EPA, 1989a) and *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (U.S. EPA, 1988a). Existing data and the data generated by

the Phase I RFI/RI will be used to begin developing and screening remedial alternatives and to estimate the risks to human health and the environment posed by sources within OU4.

1.1 ENVIRONMENTAL RESTORATION PROGRAM

The Environmental Restoration (ER) Program, designed for investigation and cleanup of environmentally contaminated sites at DOE facilities, is being implemented in five phases. Phase 1 (Installation Assessment) includes preliminary assessments and site inspections to assess potential environmental concerns. Phase 2 (Remedial Investigations) includes planning and implementation of sampling programs to delineate the magnitude and extent of contamination at specific sites and evaluate potential contaminant migration pathways. Phase 3 (Feasibility Studies) includes evaluation of remedial alternatives and development of remedial action plans to mitigate environmental problems identified in Phase 2 as needing correction. Phase 4 (Remedial Design/Remedial Action) includes design and implementation of site-specific remedial actions selected on the basis of Phase 3 feasibility studies. Phase 5 (Compliance and Verification) includes monitoring and performance assessments of remedial actions as well as verification and documentation of the adequacy of remedial actions carried out under Phase 4. Phase 1 has been completed at the Rocky Flats Plant (U.S. DOE, 1986b), and Phase 2 is currently in progress for OU4.

1.2 WORK PLAN OVERVIEW

This Work Plan presents an evaluation and summary of previous data and investigations, defines data quality objectives and data needs based on that evaluation, specifies Phase I RFI/RI tasks, and presents the FSP for the Phase I RFI/RI.

Section 2.0 (Site Characterization) presents a comprehensive review and analysis of available historical information, previous site investigations, recently published reports, available data, and past and present activities pertinent to OU4. Included in Section 2.0 are characterization results for site geology and hydrology as well as the known nature of contamination in soils, ground water, and surface water. Additionally, Section 2.0 presents a conceptual model for contaminant migration and exposure based on site physical characteristics and available information regarding the nature and extent of contamination. Section 3.0 presents potential sitewide Applicable or Relevant and Appropriate Requirements (ARARs), as required by the IAG, and a discussion of their application to the RFI/RI activities at OU4. Section 4.0 discusses the DQOs and work plan rationale for the Phase I RFI/RI. Section 5.0 specifies tasks to be performed for the Phase I RFI/RI. The schedule for performance of Phase I RFI/RI activities is presented in Section 6.0. Section 7.0 presents the

FSP to meet the objectives presented in Section 4.0. The Baseline Human Health Risk Assessment Plan is discussed in Section 8.0, and the Environmental Evaluation Work Plan (EEWP) is discussed in Section 9.0. The site-specific Quality Assurance Addendum (QAA) for OU4 is discussed in Section 10.0. Section 11.0 presents the Standard Operating Procedures (SOPs) and Procedure Change Notices (PCNs) for performing the field work.

The appendices contain available supporting information and data used to characterize the physical setting and contamination at OU4. Supporting information includes facility engineering drawings obtained from EG&G Rocky Flats, Inc. (EG&G). Supporting analytical information was obtained from existing reports and the EG&G Rocky Flats Environmental Database System (RFEDs). These data are in the process of being validated in accordance with EG&G Environmental Management (EM) Program Quality Assurance (QA) procedures. As of early 1991, only a small fraction of the data has been validated; these data are identified in the appendices by a qualifier adjacent to each datum. The qualifier "V" means the datum is valid, "A" means the datum is acceptable with qualifications (breach of QA), and "R" means the datum is rejected. Data were rejected because (1) sampling/analytical protocol did not conform to significant aspects of the QA/QC Plan (Rockwell International, 1989a) or (2) there is insufficient documentation to demonstrate conformance with these procedures. These data, at best, can be considered only qualitative measures of the analyte concentrations. The appendices also contain data from pond sludge and liquid sampling performed by Weston and summarized by Dames & Moore. These data are of significantly improved quality.

1.3 REGIONAL AND PLANT SITE BACKGROUND INFORMATION

The following subsections provide general information on RFP and the surrounding region, including RFP history, regional land use and population data, and site conditions. Site-specific conditions at OU4 are addressed in Section 2.0.

1.3.1 Facility Background and Plant Operations

RFP is a government-owned, contractor-operated facility, which is part of the nationwide Nuclear Weapons Complex. The plant was operated for the U.S. Atomic Energy Commission (AEC) from its inception in 1951 until the AEC was dissolved in January 1975. At that time, responsibility for the plant was assigned to the Energy Research and Development Administration (ERDA), which was succeeded by DOE in 1977. Dow Chemical U.S.A., an operating unit of the Dow Chemical Company, was the prime operating contractor of the facility from 1951 until June 30, 1975. Rockwell International was the prime contractor responsible for operating the Rocky Flats Plant

from July 1, 1975, until December 31, 1989. EG&G Rocky Flats, Inc. became the prime contractor at RFP on January 1, 1990.

Operations at RFP consist of fabrication of nuclear weapons components from plutonium, uranium, and other nonradioactive metals (principally beryllium and stainless steel). Parts made at the plant are shipped elsewhere for assembly. In addition, the plant reprocesses components after they are removed from obsolete weapons for recovery of plutonium. Other activities at RFP include research and development in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics. Both radioactive and nonradioactive wastes are generated in the production process. Current waste handling practices involve on-site and off-site recycling of hazardous materials, on-site storage of hazardous and radioactive mixed wastes, and off-site disposal of solid radioactive materials at another DOE facility. However, RFP operating procedures historically included both on-site storage and disposal of hazardous, radioactive, and radioactive mixed wastes. Preliminary assessments under the EM Program identified some of the past on-site storage and disposal locations as potential sources of environmental contamination.

1.3.2 Previous Investigations

Various site-wide studies have been conducted at RFP to characterize environmental media and to assess the extent of radiological and chemical contaminant releases to the environment. The investigations performed prior to 1986 were summarized by Rockwell International (1986a) and include the following:

1. Detailed description of the regional geology (Malde, 1955; Spencer, 1961; Scott, 1960, 1963, 1970, 1972, and 1975; Van Horn, 1972 and 1976; Dames and Moore, 1981; and Robson et al., 1981a and 1981b)
2. Several drilling programs beginning in 1960 that resulted in construction of approximately 60 monitoring wells by 1982
3. An investigation of surface water and ground water flow systems by the U.S. Geological Survey (Hurr, 1976)
4. Environmental, ecological, and public health studies that culminated in an Environmental Impact Statement (U.S. DOE, 1980)
5. A summary report on ground water hydrology using data from 1960 to 1985 (Hydro-Search, Inc., 1985)
6. A preliminary electromagnetic survey of the plant perimeter (Hydro-Search, Inc, 1986)

7. A soil-gas survey of the plant perimeter and buffer zone (Tracer Research, Inc., 1986)
8. Routine environmental monitoring programs addressing air, surface water, ground water, and soils (Rockwell International, 1975 through 1985, and 1986b)

In 1986, two major investigations were completed at the plant. The first was the DOE Comprehensive Environmental Assessment and Response Program (CEARP) Phase 1 Installation Assessment (U.S. DOE, 1986b), which included analyses and identification of current operational activities, active and inactive waste sites, current and past waste management practices, and potential environmental pathways through which contaminants could be transported. CEARP was later succeeded by the ER Program. A number of sites that could potentially have adverse impacts on the environment were identified. These sites were designated as solid waste management units (SWMUs) by Rockwell International (1987a). In accordance with the IAG, SWMUs are now designated as IHSSs, which were divided into three categories:

1. Hazardous substance sites that will continue to operate and need a RCRA operating permit
2. Hazardous substance sites that will be closed under RCRA interim status
3. Inactive substance sites that will be investigated and cleaned up under Section 3004(u) of RCRA or CERCLA

The second major investigation completed at the plant in 1986 involved a hydrogeologic and hydrochemical characterization of the plant site. Plans for this study were presented by Rockwell International (1986c and 1986d), and study results were reported by Rockwell International (1986e). Investigation results identified areas considered to be significant contributors to environmental contamination.

1.3.3 Physical Setting

1.3.3.1 Location

RFP is located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver (Figure 1-1). Other surrounding cities include Boulder, Westminster, and Arvada, all of which are located less than 10 miles to the northwest, east, and southeast, respectively. The plant consists of approximately 6,550 acres of federal land in Sections 1 through 4 and 9 through 15 of T2S, R70W, 6th Principal Meridian. In general, plant buildings are located within a protected central area site of approximately 400 acres, and surrounded by a buffer zone of approximately 6,150 acres.

RFP is bounded on the north by State Highway 128, on the east by Jefferson County Highway 17, (also known as Indiana Street), on the south by agricultural and industrial properties and Highway 72, and on the west by State Highway 93 (Figure 1-1).

1.3.3.2 Topography

RFP is located along the eastern edge of the southern Rocky Mountain region immediately east of the Colorado Front Range. The plant site is located on a broad, eastward-sloping pediment that is capped by alluvial deposits of Quaternary age (Rocky Flats Alluvium). The pediment surface has a fan-like form, with its apex and distal margins approximately 2 miles east of RFP. The tops of alluvial-covered pediments are nearly flat but slope gently eastward at 50 to 100 feet per mile (EG&G, 1991a). At RFP, the pediment surface is dissected by a series of east-northeast trending stream-cut valleys. The valleys containing Rock Creek, North and South Walnut Creeks, and Woman Creek lie 200 to 250 feet below the level of the older pediment surface. These valleys are incised into the bedrock underlying alluvial deposits, but most bedrock is concealed beneath colluvial material accumulated along the gentle valley slopes. The combined effects of stream-cut topographic relief and the shallow dip of the bedrock units beneath RFP suggest a potentially shallow depth to the Laramie formation in the valley bottoms.

1.3.3.3 Meteorology

The area surrounding RFP has a semiarid climate characteristic of much of the central Rocky Mountain region. Based on precipitation averages recorded between 1953 and 1976, the mean annual precipitation at the plant is 15 inches. Approximately 40 percent of the precipitation falls during the spring season, much of it as wet snow. Thunderstorms (June to August) account for an additional 30 percent of the annual precipitation. Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively. Snowfall averages 85 inches per year, falling from October through May (U.S. DOE, 1980).

Winds at RFP, although variable, are predominantly from the west-northwest. Stronger winds occur during the winter, and due to its location near the Front Range the area occasionally experiences Chinook winds with gusts up to 100 miles per hour. The canyons along the Front Range tend to channel the air flow during both up-slope and downslope conditions, especially when there is strong atmospheric stability (U.S. DOE, 1980).

Rocky Flats meteorology is strongly influenced by the diurnal cycle of mountain and valley breezes. Two dominant flow patterns exist, one during daytime conditions and one at night. During daytime hours, as the earth heats, air tends to flow toward the higher elevations (up-slope). During up-slope conditions air flow generally moves up the South Platte River Valley and then enters the canyons into the Front Range. After sunset, the air against the mountain side is cooled and begins to flow toward the lower elevations (downslope). During downslope conditions, air flows down the canyons of the Front Range onto the plains (e.g., Hodgin, 1983 and 1984; and U.S. DOE, 1986b).

Temperatures at RFP are moderate. Extremely warm or cold weather is usually of short duration. On average, daily summer temperatures range from 55 to 85 degrees Fahrenheit (°F), and winter temperatures range from 20 to 45°F. Temperature extremes recorded at the plant range from 102°F on July 12, 1971, to -26°F on January 12, 1963. The 24-year daily average maximum temperature for the period 1952 to 1976 is 76°F, the daily minimum is 22°F, and the average mean is 50°F. Average relative humidity is 46 percent (U.S. DOE, 1980).

Review of historical climatological data for RFP has indicated that some of the data are invalid under current quality standards. 1989 and 1990 RFP monthly and annual environmental monitoring reports prepared by EG&G contain climatological data that have been validated under current quality assurance protocol.

1.3.3.4 Surface Water Hydrology

Three intermittent streams that flow generally from west to east drain the RFP area. These drainages are Rock Creek, Walnut Creek, and Woman Creek (Figure 1-2).

Rock Creek drains the northwestern corner of the buffer zone and flows northeastward through the buffer zone to its off-site confluence with Coal Creek. Rock Creek is peripheral to the RFP facility, and is not known to have been impacted by RFP activities. North and South Walnut Creeks and an unnamed tributary drain the northern portion of the plant complex. These three forks of Walnut Creek join in the buffer zone and flow to Great Western Reservoir approximately 1 mile east of the confluence. Flow is diverted around Great Western Reservoir into Big Dry Creek via the Broomfield Diversion Ditch. Rock Creek, North and South Walnut Creeks, and the unnamed tributary are intermittent streams. Flow occurs in these streams only after precipitation events and spring snowmelt. An east-west trending interfluvial separates Walnut Creek from Woman Creek. Woman Creek drains the southern Rocky Flats buffer zone and flows eastward into Mower Reservoir.

The South Interceptor Ditch is located between the plant and Woman Creek. The South Interceptor Ditch collects runoff from the southern portion of the plant complex and diverts it to pond C-2, where it is monitored in accordance with RFP National Pollutant Discharge Elimination System (NPDES) permit.

1.3.3.5 Ecology

A variety of vegetation is found within the buffer zone surrounding RFP. Included are species of flora representative of tall-grass prairie, short-grass plains, lower montane, and foothill ravine regions. Riparian vegetation exists along the site's drainages and wetlands. None of these vegetative species present at RFP have been reported to be on the endangered species list (EG&G, 1991m). Since acquisition of RFP property, vegetative recovery has occurred, as evidenced by the presence of disturbance-sensitive grass species such as big bluestem (*Andropogon gerardii*) and side oats grama (*Bouteloua curtipendula*) (U.S. DOE, 1980).

The fauna inhabiting the RFP and its buffer zone consists of species associated with western prairie regions. The most common large mammal is the mule deer (*Odocoileus hemionus*), with an estimated 100 to 125 permanent residents. There are a number of small carnivores, such as the coyote (*Canis latrans*), red fox (*Vulpes fulva*), striped skunk (*Mephitis mephitis*), and long-tailed weasel (*Mustela frenata*). Small herbivores can be found throughout the plant complex and buffer zone, including species such as the pocket gopher (*Thomomys talpoides*), cottontail (*Sylvilagus sp.*), white-tailed jackrabbit (*Lepus townsendii*), and the meadow vole (*Microtus pennsylvanicus*) (U.S. DOE, 1980).

Commonly observed birds include western meadowlarks (*Sturnella neglecta*), horned larks (*Eremophila alpestris*), mourning doves (*Zenaidura macroura*), and vesper sparrows (*Pooecetes gramineus*), western kingbirds (*Tyrannus vociferans*), black-billed magpies (*Pica pica*), American robins (*Turdus migratorius*), and yellow warblers (*Dendroica magnolia*). Killdeer (*Charadrius vociferus*), and red-winged black birds (*Agelaius phoeniceus*) are seen in areas adjacent to ponds. Mallards (*Anas platyrhynchos*) and other ducks (*Anas sp.*) frequently nest and rear young on several of the ponds. Common birds of prey in the area include marsh hawks (*Circus cyaneus*), red-tailed hawks (*Buteo jamaicensis*), ferruginous hawks (*Buteo regalis*), rough-legged hawks (*Buteo lagopus*), and great horned owls (*Bubo virginianus*) (U.S. DOE, 1980).

Bull snakes (*Pituophis melanoleucus*) and rattlesnakes (*Crotalus sp.*) are the most frequently observed reptiles. Eastern yellow-bellied racers (*Coluber constrictor flaviventris*) have also been seen. The eastern short-horned lizard (*Phrynosoma douglassi brevirostre*) has been reported on the site, but these and other lizards are not commonly observed. The western painted turtle (*Chrysemys picta*) and the western plains garter snake (*Thamnophis radix*) are found in and around many of the ponds (U.S. DOE, 1980).

Two procedures which concern identification and management of threatened and endangered species at RFP currently are being prepared by the EG&G National Environmental Policy Act (NEPA) Group. These are the draft "Identification and Reporting of Threatened and Endangered and Special Concern Species," administrative procedure NEPA.12, Rev. 0, and the draft "Protection of Threatened and Endangered and Special Concern Species," operations procedure FO.21, Rev. 0.

1.3.3.6 Surrounding Land Use and Population Density

The population, economics, and land use of areas surrounding RFP are described in a 1989 Rocky Flats vicinity demographics report prepared by DOE (U.S. DOE, 1990b). This report divides general use of areas within 0 to 10 miles of RFP into residential, commercial, industrial, parks and open spaces, agricultural and vacant, and institutional classifications, and also considers current and future land use near RFP.

The majority of residential use within 5 miles of RFP is located immediately northeast, east, and southeast of the plant. The 1989 population distribution within areas up to 5 miles from RFP is illustrated in Figure 1-3. Commercial development is concentrated near residential developments north and southwest of Standley Lake as well as around Jefferson County Airport, approximately 3 miles northeast of RFP. Industrial land use within 5 miles of the plant is limited to quarrying and mining operations. Open space lands are located northeast of RFP near the City of Broomfield and in small parcels adjoining major drainages and small neighborhood parks in the cities of Westminster and Arvada. Standley Lake is surrounded by Standley Lake Park. Irrigated and non-irrigated croplands, producing primarily wheat and barley, are located northeast of RFP near the cities of Broomfield, Lafayette, and Louisville; north of RFP near Louisville and Boulder; and in scattered parcels adjacent to the eastern boundary of the plant. Several horse operations and small hay fields are located south of RFP. The demographic report characterizes much of the vacant land adjacent to RFP as rangeland (U.S. DOE, 1990b).

Future land use in the vicinity of RFP most likely involves continued urban expansion, increasing the density of residential, commercial, and perhaps industrial land use in the areas. The expected trend in population growth in the vicinity of RFP is also addressed in the DOE demographic study (U.S. DOE, 1990b). The report considers expected variations in population density by comparing the current (1989) setting to population projections for the years 2000 and 2010. A 21-year profile of projected population growth in the vicinity of RFP can thus be examined. DOE's projections are based primarily on long-term population projections developed by the Denver Regional Council of Governments (DRCOG). Expected population density and distribution around RFP for the years 2000 and 2010 are shown in Figures 1-4 and 1-5, respectively.

1.3.3.7 Regional Geology

RFP is located on a broad, eastward-sloping pediment surface along the western edge of the Denver Basin (Figure 1-6). The area is underlain by more than 10,000 feet of Pennsylvanian to Upper Cretaceous sedimentary rocks that have been locally folded and faulted. Along the foothills west of RFP, sedimentary strata are steeply east-dipping to overturned. In the western buffer zone, Upper Cretaceous sandstones of the Laramie formation make up an east-dipping (45° to 55°) hogback that strikes approximately north-northwest (Scott, 1960). Immediately west of the plant, steeply dipping sedimentary strata abruptly flatten to less than 2 degrees under and east of RFP (EG&G, 1991a). The sedimentary bedrock is unconformably overlain by Quaternary alluvial gravels that cap pediment surfaces of several distinct ages (Scott, 1965). See Figure 1-6.

Figure 1-7 shows the local stratigraphic section for the Rocky Flats area. Upper Cretaceous bedrock units directly underlying RFP and pertinent to plant site hydrogeology include, in descending stratigraphic order, the Arapahoe formation, the Laramie formation, and the Fox Hills Sandstone. These bedrock units and the overlying surficial Quaternary Deposits units at RFP are described below.

Quaternary Deposits

The Quaternary Deposits in the RFP area (Figure 1-6) have been categorized into three types of pediment cover and four types of valley fill. The Rocky Flats, Verdos, and Slocum Alluviums represent pediment covers. The valley fill alluviums include the Louviers and the Broadway Alluviums. Additional recent alluvial valley fill deposits include the Piney Creek and Post Piney Creek Alluviums. These alluvial units have been correlated along the Front Range by their stratigraphic height above modern stream drainages (EG&G, 1991i).

The Rocky Flats Alluvium is the oldest alluvial deposit in the RFP area and consists of poorly sorted, angular to rounded, coarse gravels, sands, and gravelly clay. Caliche amounts vary from trace to abundant. The alluvium occurs about 250 to 380 feet above modern stream drainages (EG&G, 1991i). Dominant lithologies include Precambrian quartzite, schist, and gneiss deposited by Coal Creek. Thickness at the type locality just south of the RFP is 50 feet, and ranges between 10 and 90 feet (Machette, 1976).

The Verdos Alluvium consists of a sandy, cobbly to bouldery gravel, deposited by Ralston Creek (Machette, 1976). The thickness ranges from 15 to 35 feet, and it occurs at 200 to 250 feet above modern streams. The Slocum Alluvium is composed of well-stratified, clayey, coarse gravel and coarse sand and its thickness ranges between 10 and 90 feet. It occurs at 80 to 120 feet above modern streams (EG&G, 1991i).

The Louviers and the Broadway Alluviums are composed of coarse sand and cobbly gravel and range between 10 and 25 feet in thickness. The Louviers Alluvium forms well-developed terraces 40 to 80 feet above modern streams. The Broadway Alluvium forms terraces between 25 and 45 feet above modern streams and occurs in channels cut into the Louviers Alluvium (EG&G, 1991i).

The Pre-Piney Creek, the Piney Creek, and Post Piney Creek Alluviums represent the most recent deposits. The Pre-Piney Creek consist of silt and sand with pebbles lenses, the Piney Creek consists of clay, silt, sand, with some pebble beds, and the Post-Piney Creek consists of poorly consolidated, humic, fine-to medium-grained sandstone interbedded with a magnetite-rich sandstone (EG&G, 1991i).

Upper Cretaceous Deposits

Depositional environments east of the Front Range in the Late Cretaceous period were influenced by the Laramide Orogeny which resulted in the uplift of the Colorado Front Range Mountains. The uplift caused a regression of the Cretaceous Sea from the west to the east, resulting in a lateral progradation of Pierre Prodelta shales and siltstones, the Fox Hills delta front sandstones, the Laramie delta plain sandstones, claystones, and coals, and Arapahoe fluvial conglomerates, sandstones and claystones (Weimer, 1976).

The above-mentioned formations are relatively distinct, from a regional perspective, reflecting increasingly higher gradients of deposition with correspondingly higher energy facies. However,

lateral and vertical variations in the depositional history of the Arapahoe Formation have been observed as a function of localized tectonic surges, creating the accumulation of higher energy, braided stream facies south of RFP in the Golden area, whereas lower energy, meandering stream facies occur in the RFP area. The Draft Final Geologic Characterization Report contains one interpretation of the sequence of deposition for the Laramie and Arapahoe formations. However, it presents two different interpretations for the depositional nature of the uppermost Arapahoe sandstones. The interpretations vary in the relative depositional gradient for the Arapahoe in the RFP area. The first interpretation assumes a single continuous meandering channel system, while the second interpretation assumes a system with multiple channels.

The gradational, transitional nature of the Laramie and Arapahoe formations makes the exact definition of the contact between the two formations difficult. A regional surface mapping project of the RFP area was conducted during 1991 as part of the site-wide Phase II Geologic Characterization efforts. Field criteria for the definition of Arapahoe sandstones included frosted, well-rounded, coarser quartz grains. However, in the subsurface, these characteristics have been observed in lower Arapahoe Formation sandstones, which were mapped as Laramie Formation during the field mapping effort. Site-wide geologic characterization investigations are continuing to resolve this issue (EG&G, 1991e).

The Arapahoe Formation is the uppermost bedrock unit underlying RFP and consists primarily as claystones and silty claystones in the RFP area. The Arapahoe Formation is approximately 150 feet thick in the center of RFP. At least five mappable sandstones have been identified within the formation. The Arapahoe Sandstone No. 1 outcrops occasionally and subcrops extensively in the RFP area. Its thickness varies between 0 and 27 feet. Its aerial extent has been mapped according to the two depositional interpretations discussed above and presented in the Draft Final Geologic Characterization Report (EG&G, 1991i).

The Arapahoe sandstones are very fine to medium grained, with some occasional conglomeratic lenses occurring. Weathered sandstones are pale orange, yellowish-gray, and dark yellowish-orange. Unweathered sandstones are light gray to olive-gray. The sandstones are typically interlayered with clay lenses and are lenticular in geometry. The dominant claystones and silty claystones are light to medium olive-gray and appear dark yellowish orange where weathered. Iron-oxide staining is common in the upper 20 feet of the sandstones (EG&G, 1991i).

The Laramie Formation consists of an upper claystone interval and a lower sandstone and coal interval and is approximately 800 feet thick. The upper Laramie Formation consists of silty claystones and siltstones, and fine-grained lenticular fluvial sandstones. The silty claystones are light olive gray to olive black, massive, occasionally sandy, and contain carbonaceous material. Siltstones are also carbonaceous, with iron oxide nodules and slickensides along fractures. The lower Laramie Formation consists of thick (up to 50 feet) sandstones and coal beds ranging from 2 to 8 feet thick. The sandstones are very fine to medium-grained.

The Fox Hills Formation averages 75 feet thick and consists of thick-bedded to massive, very fine to medium-grained feldspathic sandstone which is grayish-orange to light gray in color. The sandstones are interlayered with thin beds of siltstone and claystone (EG&G, 1991i).

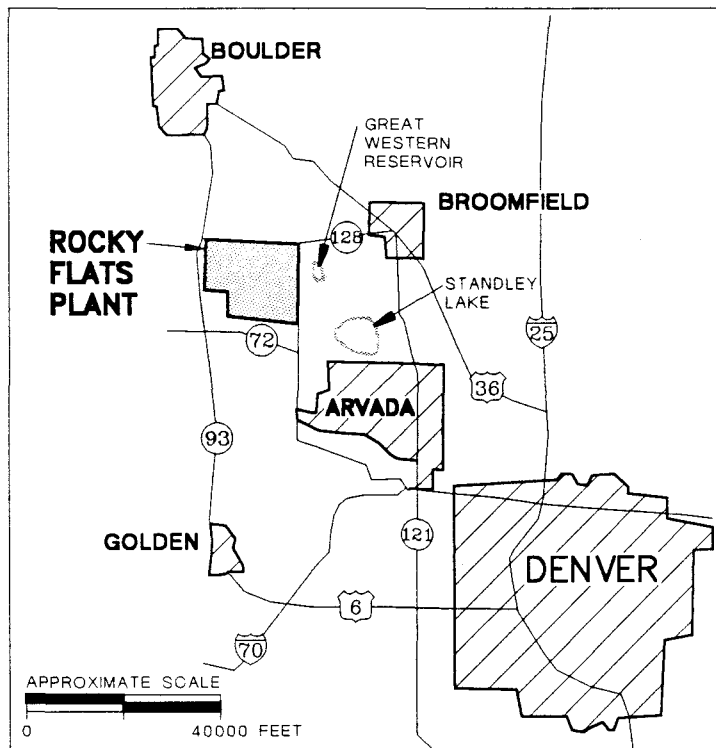
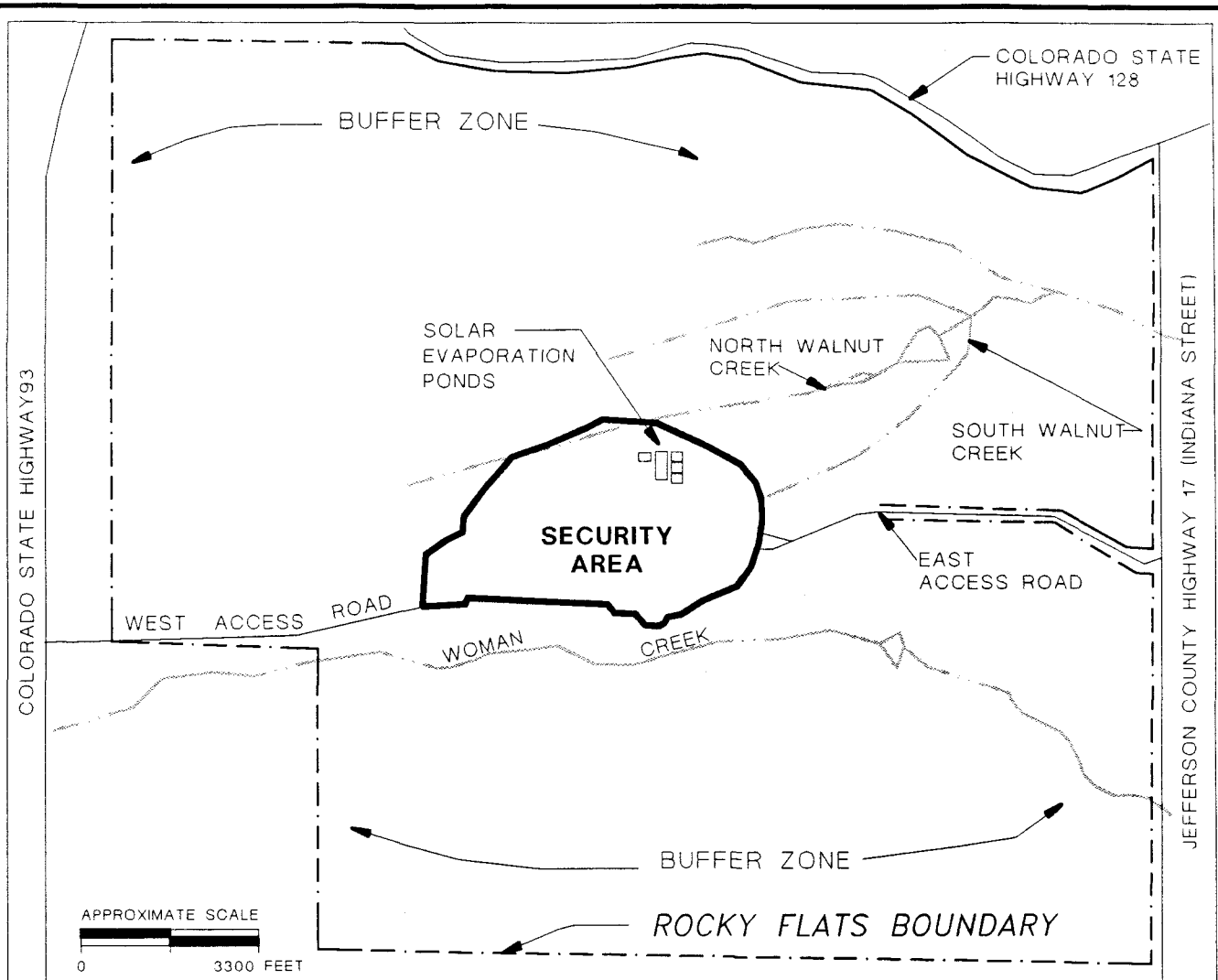
1.3.3.8 Hydrogeology

The RFP is situated in a regional ground water recharge area. Ground water recharge occurs as infiltration of precipitation, primarily where bedrock outcrops in the western portion of the RFP, along the west limb of the monoclinial fold. Recharge also occurs as a result of seepage from streams, ditches, and ponds, and into subcropping bedrock. Locally, there are areas of discharge as well as recharge. Ground water discharges to streams and along slopes as seeps. Much of the ground water within the uppermost hydrostratigraphic unit becomes surface water or evaporates as it is discharged from the ground water system at seeps along slopes and in drainage valleys (EG&G, 1991i).

Unconfined ground water at the RFP occurs in the unconsolidated alluvial material. It includes the Rocky Flats Alluvium which is present on broad topographic highs and the Valley Fill Alluvium, present in modern stream drainages. Although the water depth is variable, it becomes shallower from west to east as the alluvial material thins. In the stream drainages, seeps are common at the base of the Rocky Flats Alluvium at the contact with the claystones of the Arapahoe and Laramie Formations and where individual Arapahoe Formation sandstones crop out (EG&G, 1991i). Generally, flow in unconfined ground water at RFP is to the east.

Generally, the ground water flows along the contact of the unconsolidated material and the Arapahoe Formation claystones in a downgradient direction to the east. The claystones have a low hydraulic conductivity, on the order of 1×10^{-7} centimeters per second (cm/s), effectively constraining much of the flow within the water table aquifer to the alluvial material above the alluvial/bedrock

unconformity. Ground water in the sandstone units of the Arapahoe Formation occurs under confined conditions throughout most of the plant site. The exception to this is the occurrence of ground water in the subcropping units beneath the alluvial material. In this situation, the ground water exists under unconfined conditions. The Arapahoe No. 1 Sandstone subcrops frequently throughout the RFP area and therefore acts as an unconfined aquifer for a substantial portion of its occurrence. The lower sandstones of the Arapahoe Formation also subcrop at the unconformity, but in limited areas along valley slopes. The confining layers for the sandstones are the claystones and silty claystones of the Arapahoe Formation. The Arapahoe and the alluvial hydrostratigraphic units at RFP have relatively low hydraulic conductivities and, therefore, are not generally believed to be capable of producing economical amounts of water. The hydraulic conductivity of the Rocky Flats Alluvium and the Arapahoe No. 1 Sandstone is approximately 6×10^{-5} cm/s, as set forth in the Draft Final Ground water Protection and Monitoring Plan, June 13, 1991. The lower Arapahoe sandstones have a hydraulic conductivity of approximately 10^{-6} cm/s.



PREPARED FOR:			
U.S. DEPARTMENT OF ENERGY			
Rocky Flats Plant Golden, Colorado			
FIGURE 1-1			
TITLE:			
ROCKY FLATS LOCATION MAP			
PROJ. NO.	304909	DWG. NO.	304909-A55
DESIGN BY	G. BRAND	CHECKED	G. BRAND
DRAWN BY	R. HYNA	APPROVED	G. BRAND
DATE	10/10/91	SCALE	AS NOTED

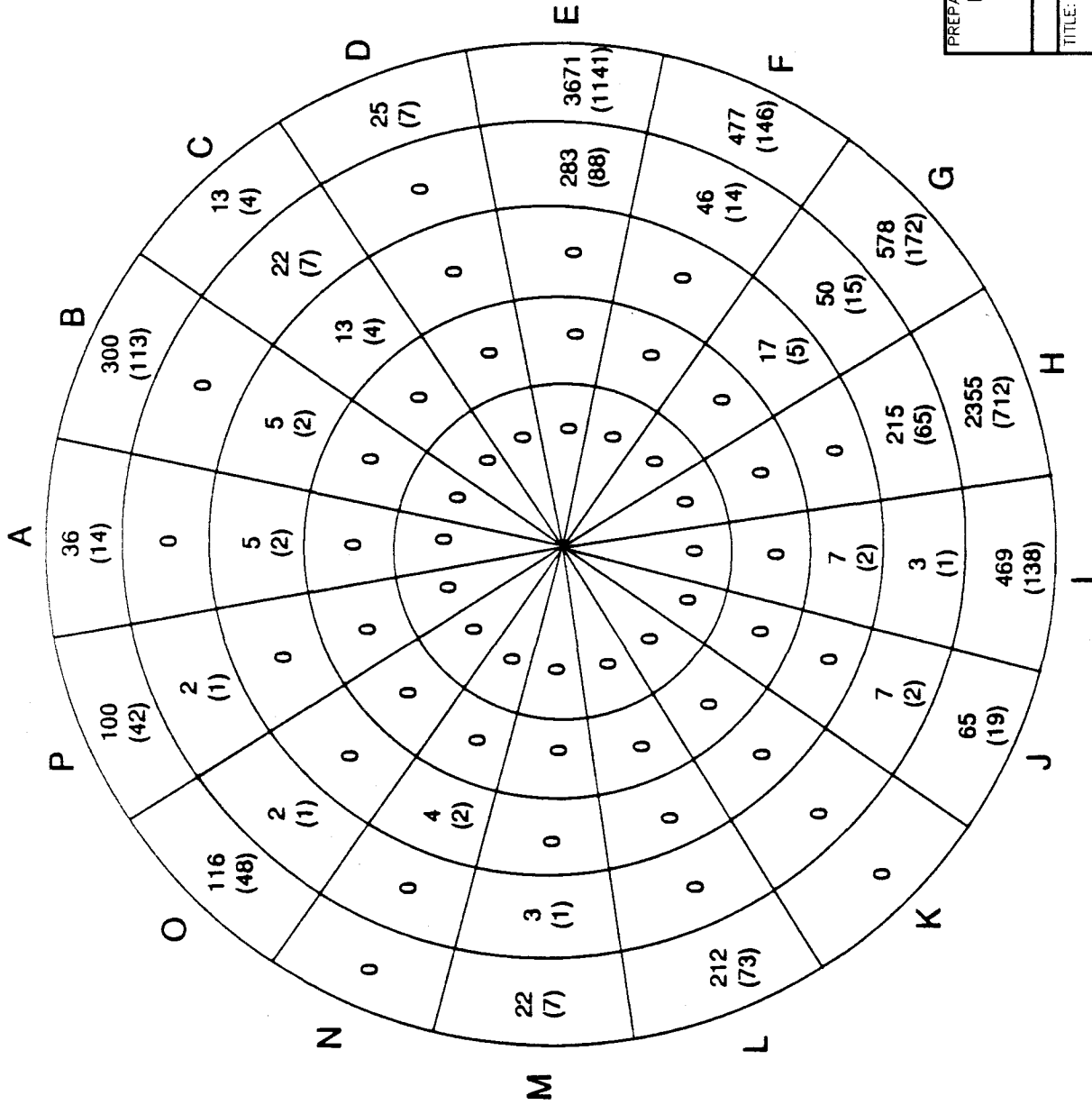
ADAPTED FROM: FIG. 1-1, E.G. & G. DRAFT GEOLOGIC CHARACTERIZATION REPORT, JAN. 3, 1990.

Sector Name

Sector 1
Sector 2
Sector 3
Sector 4
Sector 5

Miles

0-1
1-2
2-3
3-4
4-5



PREPARED FOR:

U.S. DEPARTMENT OF ENERGY

Rocky Flats Plant
Golden, Colorado

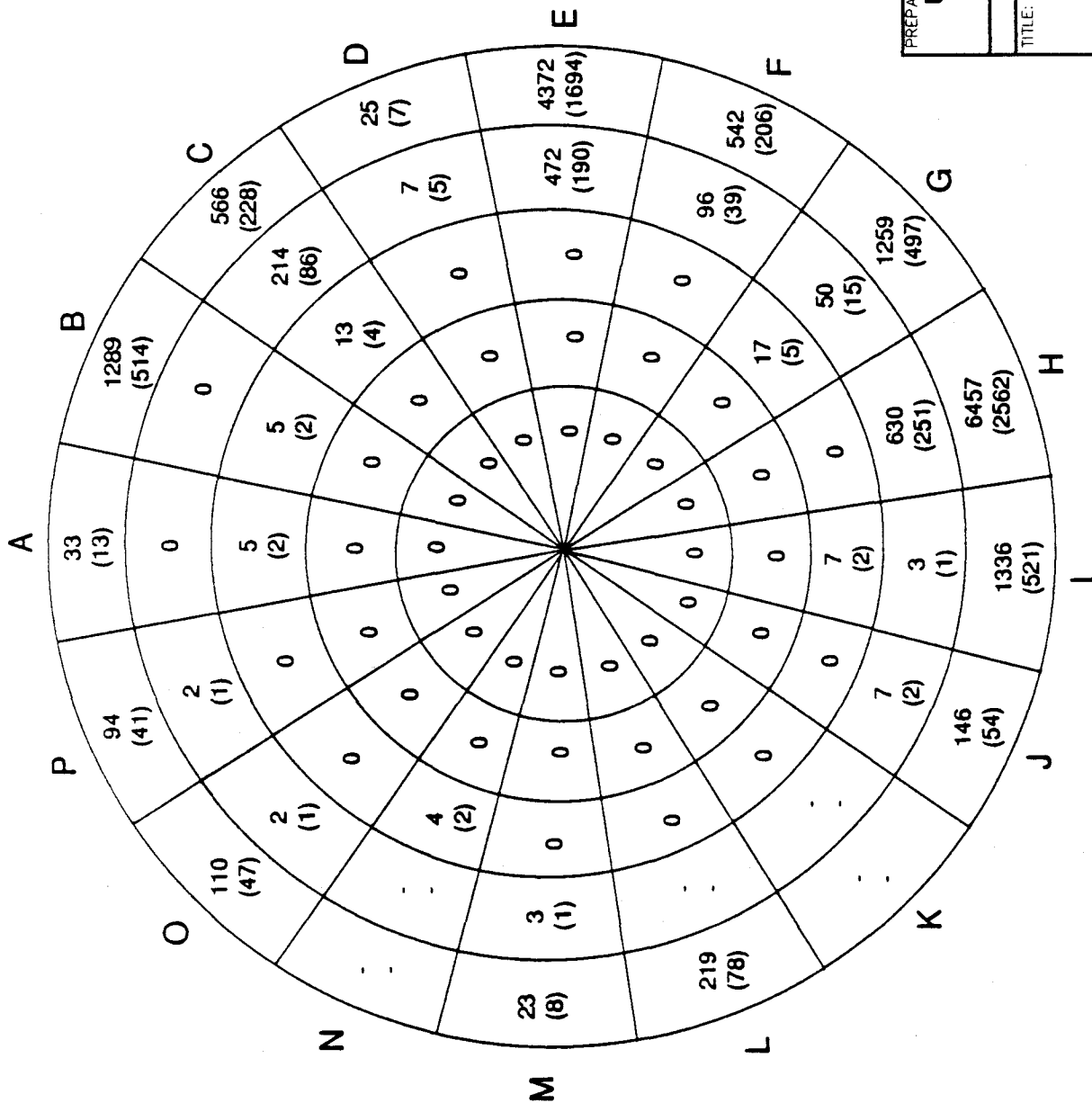
FIGURE 1-3

TITLE:

**1989 POPULATIONS AND
(HOUSEHOLDS),
SECTORS 1-5**

PROJ. NO.	304909	DWG. NO.	304909-A54	SHEET
DESIGN BY	G. BRAND	CHECKED	G. BRAND	OF
DRAWN BY	R. HYNA	APPROVED	G. BRAND	
DATE	10/10/91	SCALE	NTS	

REFERENCE: DOE, "1989 POPULATION, ECONOMIC
AND LAND USE DATA BASE FOR
ROCKY FLATS PLANT", (AUGUST 1990)



Miles
 0-1
 1-2
 2-3
 3-4
 4-5

Sector Name
 Sector 1
 Sector 2
 Sector 3
 Sector 4
 Sector 5

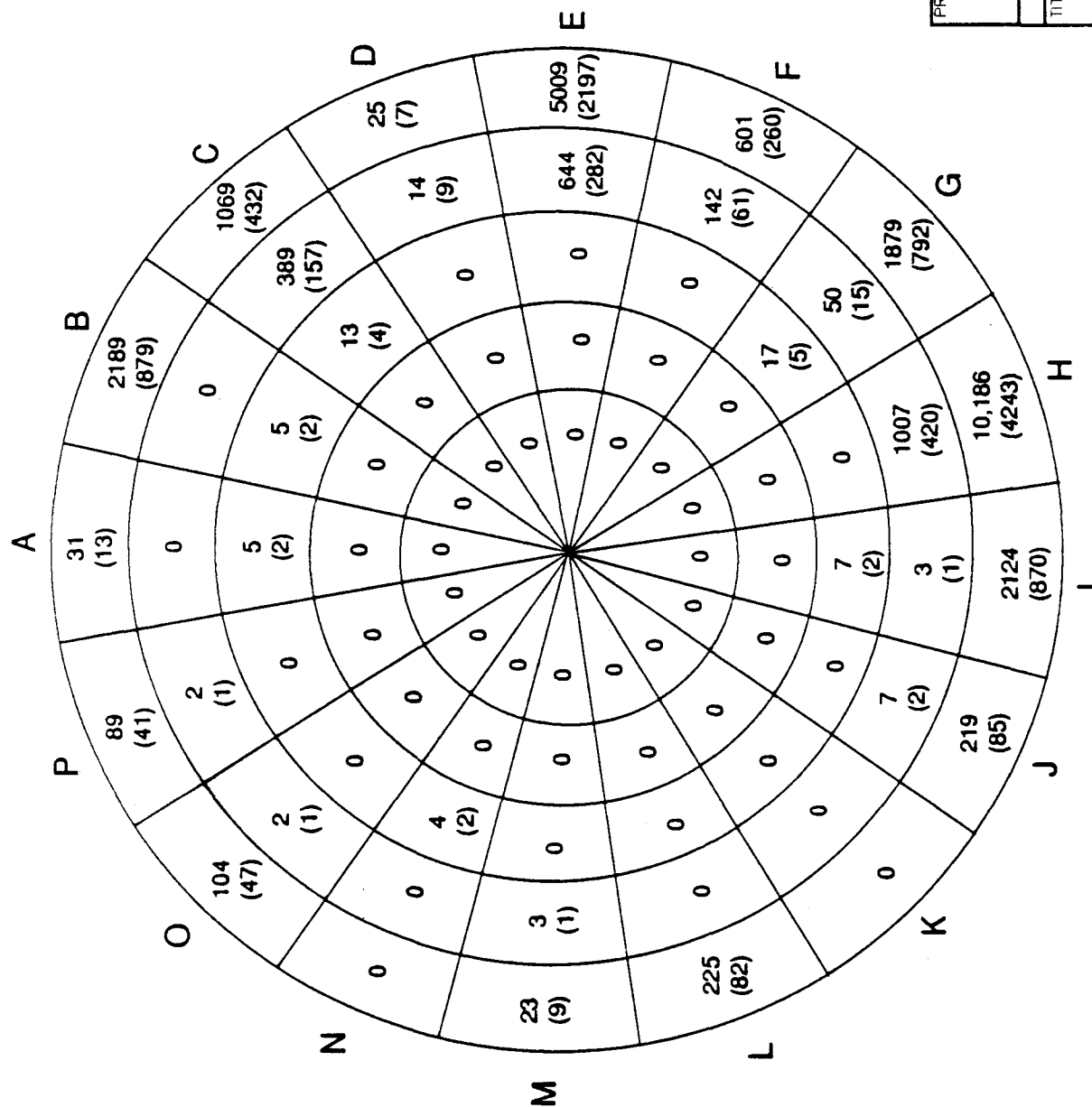
PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
 Rocky Flats Plant
 Golden, Colorado

FIGURE 1-4

TITLE:
**2000 POPULATIONS AND
 (HOUSEHOLDS),
 SECTORS 1-5**

PROJ. NO.	304909	DWG. NO.	304909-A50	SHEET
DESIGN BY	G. BRAND	CHECKED	G. BRAND	OF
DRAWN BY	R. HYNA	APPROVED	G. BRAND	
DATE	10/10/91	SCALE	NTS	

REFERENCE: DOE, "1989 POPULATION, ECONOMIC
 AND LAND USE DATA BASE FOR
 ROCKY FLATS PLANT", (AUGUST 1990)



Miles	Sector Name
0-1	Sector 1
1-2	Sector 2
2-3	Sector 3
3-4	Sector 4
4-5	Sector 5

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 Rocky Flats Plant
 Golden, Colorado

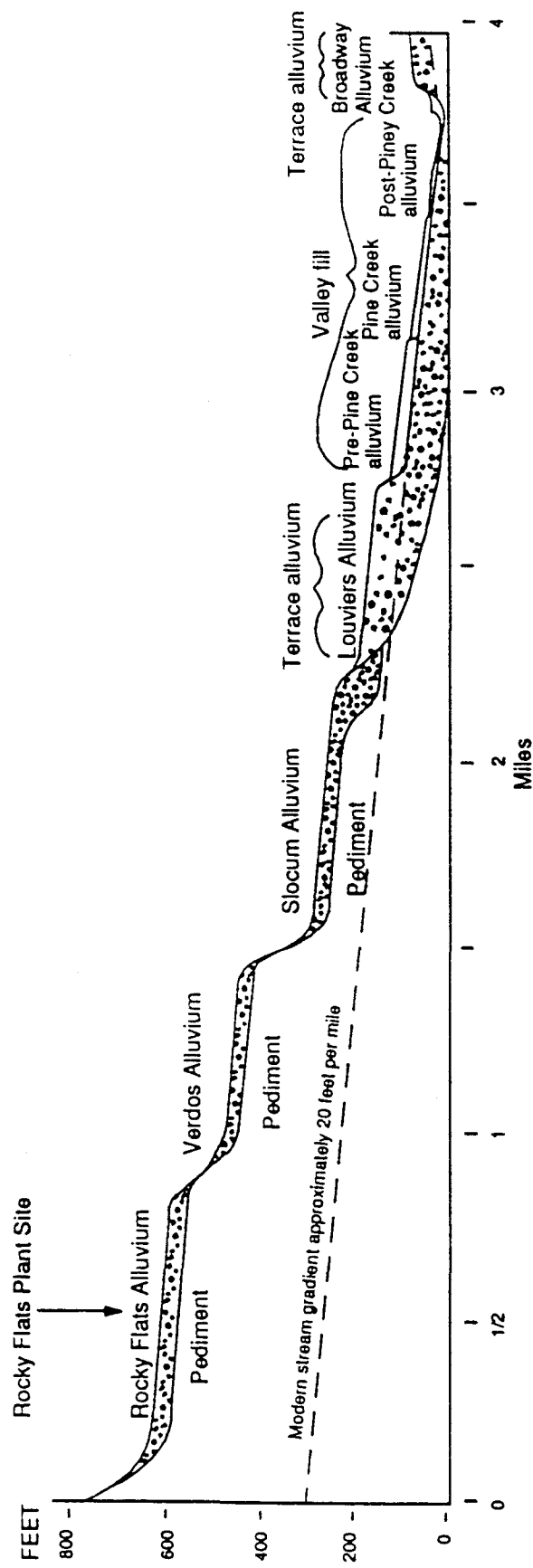
FIGURE 1-5

TITLE:
2010 POPULATIONS AND (HOUSEHOLDS), SECTORS 1-5

PROJ. NO.	304909	DWG. NO.	304909-A51	SHEET
DESIGN BY	G. BRAND	CHECKED	G. BRAND	OF
DRAWN BY	R. HYNA	APPROVED	G. BRAND	
DATE	10/10/91	SCALE	N.T.S.	

REFERENCE: DOE, "1989 POPULATION, ECONOMIC AND LAND USE DATA BASE FOR ROCKY FLATS PLANT", (AUGUST 1990)

WEST EAST



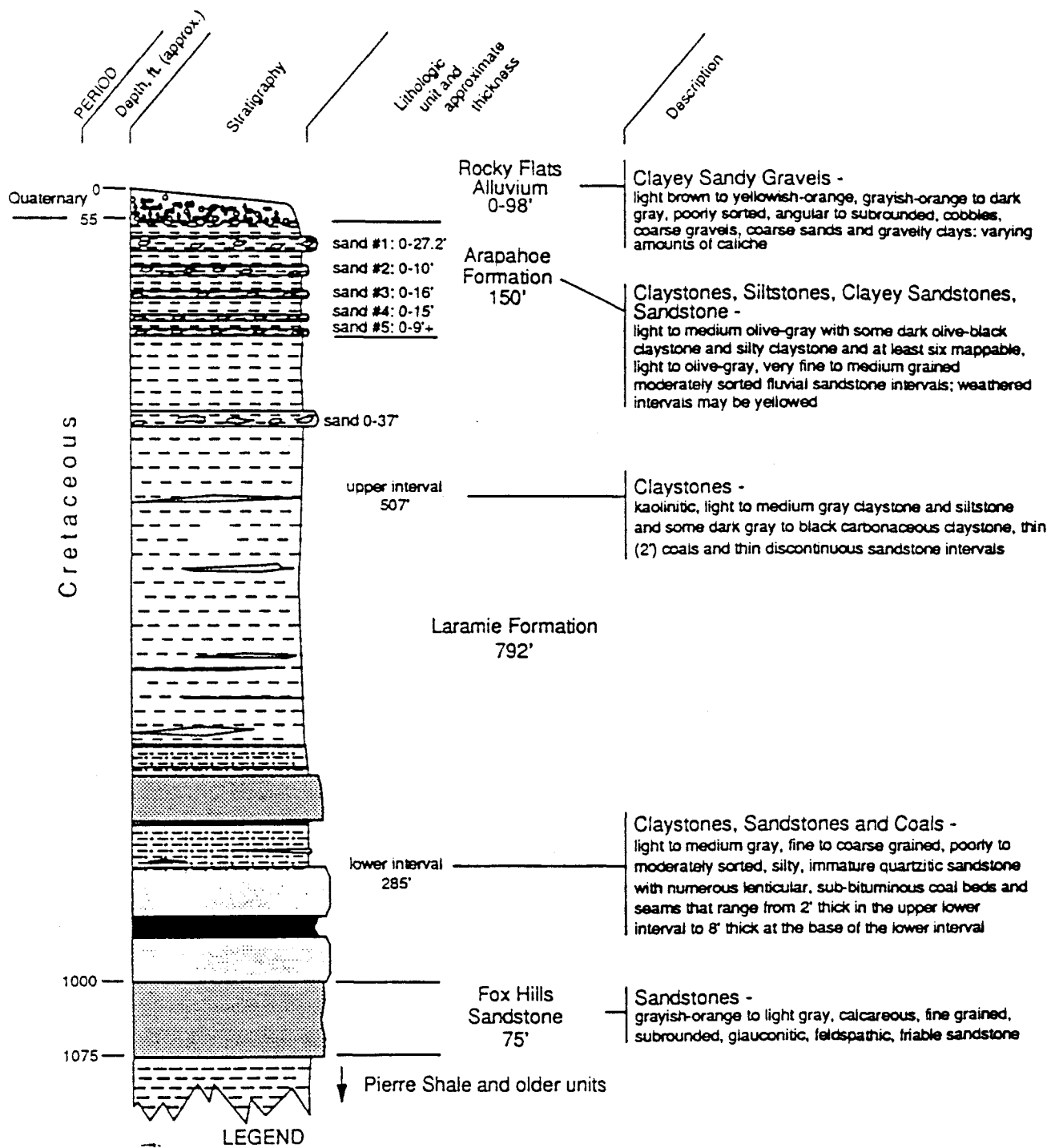
PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 1-6

**EROSIONAL SURFACES AND
ALLUVIAL DEPOSITS EAST OF
THE FRONT RANGE, COLORADO**

REFERENCE: DRAFT FINAL GEOLOGIC
CHARACTERIZATION REPORT FOR
RFP (EG&G, 1991)

PROJ. NO.	304909	DWG. NO.	304909-A52	SHEET
DESIGN BY	G. BRAND	CHECKED	G. BRAND	OF
DRAWN BY	R. HYNA	APPROVED	G. BRAND	
DATE	10/10/91	SCALE	NTS	



LEGEND

Alluvium	Fine-grained sandstone	Siltstone and claystone
Fine-grained and coarser sandstone	Silty sandstone	Coal

REFERENCE: DRAFT FINAL GEOLOGICAL CHARACTERIZATION REPORT FOR RFP (EG&G, 1991)

PREPARED FOR:			
U.S. DEPARTMENT OF ENERGY			
Rocky Flats Plant			
Golden, Colorado			
FIGURE 1-7			
TITLE:			
ROCKY FLATS PLANT			
SITE SPECIFIC			
STRATIGRAPHIC SECTION			
PROJ. NO.	304909	DWG. NO.	304909-A53
DESIGN BY	G. BRAND	CHECKED	G. BRAND
DRAWN BY	R. HYNA	APPROVED	G. BRAND
DATE	10-22-91	SCALE	NTS
			SHEET
			OF

2.0 SITE CHARACTERIZATION

The Solar Evaporation Ponds (Solar Ponds) are located in the central portion of the RFP on the northeast side of the Protected Area (PA). The Solar Ponds Waste Management Unit, which is considered equivalent to Individual Hazardous Substance Site 101 (IHSS 101), consists of five surface impoundments; Ponds 207-A, 207-B North, 207-B Center, 207-B South, and 207-C. IHSS 101 is within the OU4 boundary (Figure 2-1). The area under investigation in this Phase I work plan includes the Solar Ponds and other areas and features which are considered pertinent to the characterization of OU4. The major features in the Solar Ponds area include the Solar Ponds, the Original Pond, the Interceptor Trench System (ITS) also known as the french drain system, and areas in the immediate vicinity of the Solar Ponds (Figure 2-2). Aerial photographs of the Solar Ponds area taken in June 1991 are included in Photographs 2-1 and 2-2.

2.1 REGULATORY HISTORY OF OU4 AND INTERIM RESPONSE ACTIONS

The Solar Ponds were first identified as a RCRA regulated unit in the summer of 1986. Shortly thereafter, an interim status closure plan for the Solar Ponds was prepared in accordance with a compliance agreement. A closure plan for the interim status closure of the Solar Evaporation Ponds was required pursuant to Part 265 of the Colorado Hazardous Waste Regulations (6 CCR) and Title 40, Part 265 of the Code of Federal Regulations (40 CFR). This closure plan was revised in 1987 and again in 1988.

In late 1986, Phase I of a comprehensive program of site characterizations, remedial investigations, feasibility studies and remedial/corrective actions began at RFP. These investigations were initiated pursuant to the DOE Comprehensive Environmental Assessment and Response Program (CEARP) and Compliance Agreement finalized by representatives of the DOE and the U.S. Environmental Protection Agency (EPA) on July 31, 1986. CEARP is now known as the Environmental Restoration (ER) Program. (EG&G Rocky Flats, 1991d).

On June 28, 1989, DOE and the State of Colorado entered into the Agreement in Principle (AIP). This document stated that certain contaminated sites (e.g., the solar ponds) at RFP require special and accelerated actions. The AIP specifies in part that DOE will expedite cleanup of the Solar Ponds in order to stem the flow of harmful contaminants into the ground water and soil.

On January 22, 1991, the DOE, EPA and the State of Colorado entered into a Federal Facility Agreement and Consent Order, commonly known as the Rocky Flats Interagency Agreement (IAG). The IAG establishes the work and schedule for the RCRA Facility Investigation/Remedial Investigation (RFI/RI) and Corrective Measures Study/Feasibility Study (CMS/FS) response process. OU4 is currently in the Phase I RFI/RI stage. Phase I requires the characterization of sources and soils.

In accordance with the IAG and to fulfill the intent of the AIP, OU4 (the Solar Ponds) is presently in an Interim Measure/Interim Remedial Action (IM/IRA) process. The IM/IRA is being taken as an enabling action to facilitate waste removal operations, cleanout of the ponds, and site closure. Changes to the operation of the Solar Ponds are required to allow the dewatering of liquids and removal of sludges from the ponds. The IM/IRA proposes an alternate means of storing water collected by the Interceptor Trench System (ITS), and a means to treat these collected waters and excess liquids currently contained in the Solar Ponds.

2.2 BACKGROUND AND PHYSICAL SETTING OF OU4

The Solar Ponds were constructed primarily to store and treat by evaporation low-level radioactive process wastes containing high nitrates, and neutralized acidic wastes containing aluminum hydroxide. During their use, these ponds are known to have received additional wastes such as sanitary sewage sludge, lithium metal, sodium nitrate, ferric chloride, lithium chloride, sulfuric acid, ammonium persulfates, hydrochloric acid, nitric acid, hexavalent chromium and cyanide solutions (Rockwell International, 1988a). Solvents and other organics have not been routinely discharged to the ponds. It was felt that organics would lead to algal growth which would diminish solar evaporation. However, low concentrations of solvents may have been present as a minor constituent in other aqueous wastes. The Original Pond was constructed in 1953 and used continuously until 1956, when its regular use was discontinued. Pond 207-A was placed in service in August 1956. Ponds 207-B North, Center, and South were placed in service in June 1960. Pond 207-C was constructed in 1970 to provide additional storage capacity and to allow the transfer and storage of liquids from the other ponds in order to perform pond repair work. The use of individual ponds has changed over time. Sludges from the Solar Ponds have been removed from time to time to implement repair work on the pond liners and as part of routine waste management activities. As the sludges were removed, they were mixed with Portland cement and solidified as a mixture of sludge and concrete (pondcrete) for shipment to an off-site low-level radioactive waste disposal site.

The routine placement of process waste material into the Solar Ponds ceased in 1986 because of changes in RFP waste treatment operations. Presently, Pond 207-A is nearly dry containing a small volume of intercepted seepage and ground water collected by the ITS. The 207-B ponds continue to be used for storage and treatment of intercepted water collected by the ITS. Pond 207-C continues to store and treat process waste.

Nitrite contamination of North Walnut Creek, located north of the Solar Ponds, was documented in the early 1970s. In response to this contamination, a series of trenches and sumps were installed north of the Solar Ponds during the period of 1971 to 1974. The trenches and sumps collected seepage and ground water, and were in operation until the 1980s when they were replaced by a more extensive french drain system (the ITS). The ITS is currently in use. Water collected by the ITS flows by gravity to the Interceptor Trench Pump House (ITPH). From there the water is currently pumped to Pond 207-B North. The current amount of intercepted seepage collected by the ITS is estimated to be approximately 4 million gallons per year.

Specific details concerning the construction and use of each pond, the trenches and the ITS are contained in subsequent sections. A summary of major events which have occurred at the Solar Ponds is included in Figure 2-3. Additional construction drawings are contained in the 1988 Solar Evaporation Ponds Closure Plan (Rockwell International, 1988a) and in Appendix A of this Work Plan.

2.2.1 The Original Pond

The Original Pond consisted of a clay lined impoundment, constructed in December 1953, in the vicinity of the existing Pond 207-C. Figure 2-2 shows the approximate location of the original and existing ponds. Photograph 2-3, taken in September 1956, also shows the Original Pond in relation to Pond 207-A. Photograph 2-3 is an easterly view from the west side of the Original Pond with Pond 207-A in the background. The Original Pond consisted of two cells which measured approximately 100 by 200 feet and 200 by 200 feet. The Original Pond was operated with both cells until 1956, when its regular use was discontinued. Based upon aerial photographs, one of the two cells may have contained liquids one or more times since 1963. Aerial photographs also indicate that the location of the Original Pond was regraded in 1970, during the construction of Pond 207-C. Soil from the area of the Original Pond may have been used in the construction of Pond 207-C. Additional drawings obtained from EG&G Facility Engineering are included in Appendix A of this Work Plan.

2.2.2 Solar Evaporation Pond 207-A

Pond 207-A was placed in service in August 1956. The original construction consisted of asphalt planking approximately 1/2-inch thick (Figure 2-4). Photograph 2-4, taken in May 1956, depicts this installation. It is believed that Pond 207-A entered service shortly after construction. Pond 207-A is approximately 250 feet by 525 feet at the crest. When operating at its maximum allowable level, the ponds' liquid covers an area of approximately 230 feet by 505 feet. This corresponds to a surface area of approximately 116,200 square feet (about 3 acres). The maximum operating depth is approximately 7½ feet corresponding to a maximum waste volume of about 5,050,000 gallons (Rockwell International, 1988a).

Pond 207-A was redesigned in November 1963 (Figure 2-5). At this time, the asphalt planking was replaced with an approximate four-inch thickness of asphaltic concrete. The slopes of both the pond bottom and the pond sides were significantly modified. Based on these modifications, the bottom slope of the pond drained to a sump at the northeast end of the pond, and the side slopes, which had been 1:2, were changed to 1:3.7. Pond 207-A received process wastes until 1986, at which time dewatering and sludge removal operations began. Sludge was removed, thickened, and mixed with Portland cement to produce a material called pondcrete, which was then disposed off-site. As sludge was being removed from Pond 207-A, the removal of water from the pond was also conducted by natural and forced evaporation via evaporators located in Building 374. As a result of these efforts, Pond 207-A was essentially empty of materials by the summer of 1988. The last few hundred gallons of water were transferred to the 207-B ponds in order to allow the bottom to be inspected and relining operations initiated. The side slopes of Pond 207-A were relined in the Fall of 1988 to repair cracks in the side slopes as a part of the closure operations. This relining consisted of a minimum of 1/8-inch thick, rubberized, crack-sealing material, laid over the side slopes of the pond. Relineing was performed to minimize potential leakage from the pond in preparation for the transfer of pumped-back ground water into the pond for evaporation. These activities were discussed with the CDH and the EPA, and proceeded as per agreements made with those agencies.

In March 1990, pumped-back ground water contained in the 207-B ponds was transferred into Pond 207-A to prevent overtopping of the 207-B ponds. Presently, Pond 207-A contains only a small volume of water and sludge which has ponded in the northeast corner of the pond. An aerial photograph taken in June 1991, Photograph 2-5, shows a southerly view of Pond 207-A and the 207-B ponds.

2.2.3 Solar Evaporation Ponds 207-B North, Center, and South

Ponds 207-B North, Center, and South were placed in service in June 1960. These ponds were also originally lined with asphalt planking (Figure 2-6). Based upon available records, it appears that the 207-B ponds were relined shortly after being placed into service. The asphalt planking was covered with asphaltic concrete at 207-B South in November 1960, and at 207-B North and Center in August 1961.

Ponds 207-B North, Center, and South are each approximately 180 feet by 253 feet at the crest. When operating at their maximum allowable level, the ponds' liquids cover areas of approximately 175 feet by 245 feet. This corresponds to surface areas of approximately 42,900 square feet each (about 1 acre). Ponds 207-B North and Center have maximum operating depths of approximately 6½ feet with maximum waste volumes of approximately 1,550,000 gallons each. Pond 207-B South has a maximum operating depth of approximately 5½ feet corresponding to a maximum waste volume of about 1,400,000 gallons (Rockwell International, 1988a).

Until 1977, the three 207-B ponds had held process waste. After preliminary work was performed in 1976, the sludge from all of the 207-B ponds was removed in 1977. The liners of the 207-B Center and South ponds were also removed and disposed of off-site, and new liners were installed in these ponds. Pond 207-B South received a 45 mil thick synthetic Hypalon liner, and a leak detection system was designed for placement between the Hypalon liner and the asphalt concrete liner. The 207-B North pond contained almost no sludge and, therefore, did not have the liner removed; however, the existing liner was repaired. These activities were performed as part of the construction of the Reverse Osmosis (RO) facility and the related plant water recycle activities. Since the 1977 cleanout, the 207-B ponds have not contained process waste (Rockwell International, 1988a). These ponds have held treated sanitary effluent, treated water from the RO facility, backwash (brine) from the RO facility, and contaminated ground water pumped back to Pond 207-B North from the ITS.

Presently, the 207-B ponds are approximately filled to one-quarter to one-half capacity. They continue to receive, store and treat contaminated ground water pumped back from the ITS. An aerial photograph taken in June 1991, Photograph 2-5, shows a southerly view of the 207-B ponds and Pond 207-A.

2.2.4 Solar Evaporation Pond 207-C

Pond 207-C was placed in service in December 1970. As illustrated in Figure 2-2, Pond 207-C was constructed in the vicinity of the Original Pond. Pond 207-C has an asphaltic concrete liner system, a leak detection system, and its bottom slopes to the northeast (Figure 2-7). It is believed that Pond 207-C has not been relined since construction.

Pond 207-C is approximately 160 feet by 250 feet at the crest. When operating at its maximum allowable level, the ponds' liquid covers an area of approximately 155 feet by 245 feet. This corresponds to a surface area of approximately 38,000 square feet (about 0.9 acre). The pond has a depth of approximately 7 feet with a maximum waste volume of about 1,150,000 gallons (Rockwell International, 1988a).

Although Pond 207-C has not received process wastes since 1986, it continues to store and treat (by evaporation) these wastes. Pond 207-C is presently filled to approximately one-half capacity. An aerial photograph taken in June 1991, Photograph 2-6, shows a southerly view of Pond 207-A and Pond 207-C.

2.2.5 Trenches and Sumps

Operational History of Trenches and Sumps

Nitrate contamination of North Walnut Creek, located to the north of the Solar Ponds, was documented in the early 1970s. In response to this contamination, a series of trenches and sumps were installed north of the ponds during the period of 1971 to 1974. Trenches 1 and 2 were installed in October 1971, Trench 3 in September 1972, Trenches 4 and 5 in April 1974, and Trench 6 in July 1974 (Figure 2-2). Trench 5 drained by gravity to Trench 4. Water from Trench 4 was pumped to Trench 3, and Trench 3 returned the water to Pond 207-A. Water collected in Trenches 1 and 2 was pumped uphill into sumps, after which the water was returned to Ponds 207-B North and 207-A.

The locations of the sumps and trenches were established based upon evidence of nitrate-impacted vegetation. The water present in these areas was sampled, and if the presence of nitrate contamination was confirmed, a trench was typically installed. These trenches and sumps intercepted natural seepage and pond leakage that might otherwise have entered North Walnut Creek, and were successful in reducing nitrate levels in North Walnut Creek (ASI, 1991).

In addition to the trenches and sumps described above, an additional control structure was built to transfer water to Pond 207-A. This structure consisted of a pump-well with a submersible pump located in the area in which footing drain flows from Buildings 771 and 774 could be collected. The purpose of the system was to better manage contaminated water. The footing drain flows both surface in the general location of the small pond due east of the currently unused condensate tanks that are north of Building 774. The pump would remove water from the area in which the footing drains surface and pump the water to Pond 207-C. It is believed that this system was constructed in approximately 1975. This structure is sometimes referred to as the West Collector (ASI, 1991).

The trenches and sumps were in operation until the early 1980s when they were replaced by a more extensive french drain system (the ITS). The trenches and sumps that were not destroyed in construction related to the PSZ were abandoned in-place by cutting their electrical power supply.

2.2.6 Interceptor Trench System

The Interceptor Trench System (ITS), also known as the French Drain System, was installed as a part of the construction of the Perimeter Security Zone (PSZ) at the Rocky Flats Plant. This ground water and seepage collection system was designed and constructed to minimize the seepage of waters into North Walnut Creek. The depths of the french drains range from approximately 1 to 27 feet below the ground surface, with typical depths of 4 to 16 feet (Rockwell International, 1988a). The gravel-filled trenches of the french drains are approximately one foot wide, with perforated pipe in the bottom to intercept and transport flow to the Interceptor Trench Pump House (ITPH). A cross section through most of the ITS is similar to the cross section presented in Figure 2-8 for the trenches.

A portion of the ITS was designed to collect surface runoff in addition to ground water and seepage. French drains in this portion were filled with gravel to the ground surface rather than capped with backfill. This portion of the system is present immediately north of the Solar Ponds and is identified in Figure 2-2 as segment D-D'.

One portion of the ITS was extended to the west to collect flow from Buildings 771 and 774 footing drains. The portion of the ITS collecting this flow is identified on Figure 2-2 as segment E-E'.

Ground water collected in the ITS flows by gravity to the ITPH. The liquid from the pump house is then pumped to Pond 207-B North. The current amount of ground water and seepage collected

by the ITS is estimated to be approximately 4 million gallons per year. The maximum amount of water collected in any one week was 700,000 gallons in June 1987 (Rockwell International, 1988a).

2.3 PREVIOUS INVESTIGATIONS

A number of previous investigations have been conducted at site for the purpose of evaluating physical characteristics, including surface water and ground water flow and quality. Previous studies that were the primary sources of information for this Work Plan include:

- ASI; Solar Ponds Interceptor Trench System Ground Water Management Study, Rocky Flats Plant Site, Task 7 of the Zero-Off-site Water-Discharge Study; January 15, 1991
- Dames & Moore; Summary of R.F. Weston's Sampling and Analysis of Solar Pond Water and Sludge Report; Rocky Flats Plant, Golden, Colorado; September 18, 1991
- EG&G Rocky Flats, Inc.; Draft Final Geologic Characterization Report for RFP; July 1991
- EG&G, Draft Well Abandonment and Replacement Program Work Plan for Rocky Flats Plant; June 1991
- EG&G Rocky Flats, Inc.; 1990 Annual RCRA Ground Water Monitoring Report for Regulated Units at Rocky Flats Plant Volume I; March 1, 1991
- EG&G Rocky Flats, Inc.; Final Background Geochemical Characterization Report: Rocky Flats Plant for 1989; December 1990
- 1989 Soil Boring Program summarized in the EG&G RFEDs (database)
- Hydro-Search, Inc.; Hydrogeologic Characterization of the Rocky Flats Plant, Golden, Colorado; Project Number 1520; 55 p.; December 9, 1985
- Rockwell International; Closure Plan: Solar Evaporation Ponds; U.S. Department of Energy; Rocky Flats Plant, Golden, Colorado; Volumes I through IV; Unnumbered Report; 1988
- Roy F. Weston, Inc.; Sampling and Analysis of Solar Pond Water and Sludge; EG&G Rocky Flats, Inc.; Rocky Flats Plant, Golden, Colorado; July 19, 1991
- U.S. DOE, Draft Phase I RFI/RI Work Plan for the Solar Evaporation Ponds (OU4); Rocky Flats Plant, Golden, Colorado; June 1990.

The following is a brief description of some of the investigations which have been conducted in and around OU4. Some of the earlier investigations have not been referenced extensively in this Work Plan and hence do not appear in the list above.

In 1970, Woodward-Clyde and Associates conducted an investigation of a potential landslide area north of the Solar Ponds. Test holes were drilled to assist in the determination of subsoil and ground water conditions and evaluate landslide risk. Ten test holes were drilled, and up to 6 feet of fill was encountered, underlain by 5 to 21 feet of clay, clayey gravel and sand, and weathered claystone. Also, free water was encountered in all test holes. The study concluded that the hillside below the ponds is a high risk area for landsliding, particularly with the probable addition of subsurface water flows from the ponds. In addition, it was recommended that a drainage system to remove subsurface water be installed (Woodward-Clyde & Associates, 1970).

Engineering Science, Inc. (1975) conducted an investigation concerning the problem of nitrate salts being transported from the Solar Ponds area into North Walnut Creek. Ten holes were drilled along the north and east exterior of the Solar Ponds and 21 additional test holes were drilled down the north slope of the ponds to determine the distribution of contaminated soil. These holes were terminated in bedrock and samples were collected for laboratory analysis. Findings from this study indicated that soils north and east of the Solar Ponds were contaminated with nitrate and that these nitrates would continue to be leached from the contaminated soil and be transported to North Walnut Creek (Engineering Science, 1975).

Another geotechnical investigation was conducted in 1984 by Geotechnical and Materials. Two exploratory test borings were drilled southeast and east of Pond 207-C to describe the subsurface conditions and recommend suitable types and depths of foundations for proposed new structures. These borings terminated approximately 14 feet below the existing grade in overburden materials. This study concluded that the proposed structures could be founded on spread footings, ring-wall, or mat foundations bearing on the in situ soils (Geotechnical and Materials Consultants, 1984).

Hydro-Search, Inc. (1985) presented a site-wide hydrogeologic characterization of the RFP. This report describes the hydrogeologic and ground water quality conditions based on existing data at the time. The existing ground water monitoring system was described and evaluated, and recommendations were made for a new monitoring program (Hydro-Search, 1985).

In 1986, R. L. Henry (Rockwell International) submitted a report summarizing trends observed in the surface water monitoring at the RFP. The report discusses the surface water control system (SWCS) completed in 1980, which is designed to divert flow around the RFP and collect surface runoff and store it temporarily for monitoring before discharge. Nonradioactive and radioactive trends in the surface water were also discussed (Henry, R.L., 1986).

In 1986, Chen and Associates prepared a closure plan for the Solar Ponds. The plan describes the construction and operation procedures at the Solar Ponds including past use, size and volume of impoundments, waste inventory, and treatment and disposal of wastes. This closure plan was revised in 1987 and again in 1988 (Rockwell International, 1988a).

Twenty-one ground water monitoring wells were installed in 1986. These wells were installed to characterize the hydrogeology in the Solar Ponds area and to evaluate if the Solar Ponds were an imminent threat to the public or the environment.

Chen and Associates prepared a preliminary prioritization of sites at the RFP. The prioritization of sites was based on review of previous investigations and historical aerial photographs. The Solar Ponds were considered a priority site (U.S. DOE, 1986a).

In 1987, six monitor wells and 14 boreholes were drilled for characterization of the Solar Ponds area. Results of this drilling program are presented in Volume II of the 1988 Closure Plan (Rockwell International, 1988a).

In 1989, 32 monitoring wells were installed in the Solar Ponds area by Rockwell International. During the drilling, soil samples were collected for chemical and/or radiological analysis. Water levels and the results of ground water sample analysis from these wells are reported in 1989 Annual RCRA Ground Water Monitoring Report for Regulated Units at Rocky Flats Plant (EG&G, 1990a). Soil sample analytical results are in the RFEDs database and general conclusions of the results discussed in this Work Plan. No report is available summarizing the 1989 soil sampling program at the Solar Ponds.

2.4 SITE GEOLOGY AND HYDROLOGY

2.4.1 Site Geology

Numerous investigations have focused on the geology of the RFP including extensive drilling in the Solar Ponds area. The following discussion of site geology has taken into consideration the results of the Solar Evaporation Ponds Closure Plan (Rockwell International, 1988a), the 1989 drilling program performed by Weston, EG&G Rocky Flats Summary of Field Investigations and EG&G Rocky Flats Draft Final Geologic Characterization Report (EG&G, 1991i).

Figure 2-9 shows the locations of monitoring wells and soil borings utilized in preparation of this Work Plan. The locations of boreholes, data for which were also used, are shown in Figure 2-23. Figure 2-9 also shows the locations for cross sections A through D presented in Figures 2-10, 2-11, 2-12, and 2-13. Cross sections A through D show the bedrock elevation and alluvial thickness. Figure 2-14 illustrates the bedrock geology. Original borehole lithology and construction logs are contained in Appendix B. Many of the logs were revised as a result of re-logging the cores, during 1989 and 1990. The revised borehole data have been summarized for all RFP areas in the Draft Final Geologic Characterization Report (EG&G, 1991i). A separate spreadsheet containing only the borehole data pertaining to the Solar Ponds area was developed as a subset of the spreadsheet summary for all RFP data. This spreadsheet is also contained in Appendix B, and has been relied upon for the development of the cross sections and bedrock map. Total depth of the 78 borings ranges from 7 to 157 feet, and averages 34 feet.

Geologic interpretations presented in the maps and cross sections are based primarily on the borehole spreadsheet data contained in Appendix B, which represent the most consistent and accurate data available to work with. However, because the spreadsheet data account for only sandstone lithologies below the surface of the bedrock, original logs were utilized to delineate non-sandstone lithologies below the bedrock surface on the cross sections. Many of the original borehole logs disagree with the spreadsheet data, as a result of the re-logging activities discussed above. The cross sections show all unconsolidated materials grouped into a single unit referred to as Rocky Flats Alluvium. This includes the Rocky Flats Alluvium, which is predominantly a gravel and caps the erosional highs, as well as the Colluvium and Valley Fill which are predominantly clays. These units are discussed separately below. The cross sections contain additional data pertaining to well completion and water levels. The well completion data are summarized in Table 2.4 and the water level data are taken from the 1990 Annual RCRA Ground Water Monitoring Report (EG&G, 1991d).

The cross sections and the bedrock geology map show the presence of a partially developed Arapahoe Sandstone channel system, grading from claystone boundaries to silty claystones, siltstones, and sandstone lenses within the channel. The sandstones are best developed at the bedrock surface underneath Pond 207-C and to the southeast of the 207-B ponds along South Walnut Creek. The 1988 Closure Plan identified a sandstone lens at the southeast corner of Pond 207-A, based on a sandstone described at the bedrock surface in borehole SP 04-87. Re-logging efforts have since determined only the presence of claystone as is indicated in the borehole spreadsheet data, and is shown on the Bedrock Geology Map. A smaller sandstone subcrops to the north of Pond 207-A in North Walnut Creek. This sandstone was encountered with borehole SP 11-87. East-west cross sections B-B', C-C', and D-D' show the presence of lower sandstone units, extensive silty claystones and siltstones at the south end of the area, and subcropping sandstones becoming more dominant to the north. Bedrock becomes more shallow in the north end of the area. Lower sandstone units in cross sections B-B' and D-D' were not encountered in any of the shallow borings in C-C', but are likely to be present. No attempt was made to correlate or project the presence of the sandstones in the cross sections. Cross section A-A' (looking west) suggests the presence of a channel system. The more erosion resistant sandstones and silty claystones in this area have formed an erosional high.

2.4.1.1 Surface Geology

The Solar Ponds are located on a Pre-Wisconsin pediment remnant, referred to as part of the Plant Interfluvium. The pediment is capped by the Rocky Flats Alluvium. Cross sections A through D illustrate the bedrock elevation and the overlying unconsolidated materials. The pediment erosional surface was cut by west-to-east flowing streams, which are believed to have had as much as 30 feet of cross-section relief. Later erosion was possibly controlled by Pre-Wisconsin topography, ultimately breaching the alluvial cover, exposing bedrock units and following the earlier defined drainage systems.

The Quaternary deposits of the RFP area are described in Section 1.3.3.7. The Rocky Flats Alluvium is the only Quaternary deposit underlying the Solar Ponds area. Other more recent unconsolidated deposits have been identified at the Solar Ponds area and are discussed in detail below (Rockwell International, 1988a). Most of the Solar Ponds area has been disturbed by construction of the ponds and the ITS, as well as nearby buildings and other infrastructure. Rocky Flats Alluvium often occurs below the limits of the disturbed ground, according to borehole logs. All unconsolidated units have been grouped together as Rocky Flats Alluvium in the cross sections,

for ease of illustration. Thickness of the entire unconsolidated interval ranges from 0 to 27 feet, with an average of 10 feet.

Rocky Flats Alluvium

The Rocky Flats alluvium occurs on top of the erosional bedrock highs in the Solar Ponds area and is generally poorly sorted containing a range of clay, silt, sand, and gravel deposits. Colors vary from light brown to gray brown, dark yellowish-orange, grayish-orange, and dark gray. The material is mildly calcareous and weakly cemented in areas. It also contains occasional boulders and re-worked bedrock materials, which can cause problems in distinguishing the true bedrock surface during drilling.

Colluvium

Colluvium occurs on the hill slopes northeast and southeast of the Solar Ponds descending to North and South Walnut Creeks. It consists of unconsolidated clay with silty clay, sandy clay, and gravel layers. Colors vary from dark yellowish-brown to light olive gray and light olive brown. Occasional dark yellowish-orange iron staining is present. Occasional cobbles occur in the gravel layers.

Valley Fill Alluvium

Valley fill alluvium occurs in the drainages of North and South Walnut Creek and consist of unconsolidated, poorly sorted sand, gravel, and pebbles in a silty clay matrix. Colors range from olive gray to dark yellowish-orange to dark yellowish-brown.

Disturbed Ground

Disturbed ground overlies the Rocky Flats Alluvium in the ponds area, and the colluvium on the hill slopes in the ITS area. Disturbed ground consists of unconsolidated clay, silt, sand, gravel, and pebbles. Colors range from olive to reddish brown to yellow gray and yellow orange.

Artificial Fill

Artificial fill occurs in close proximity of the ponds and contains materials that have obviously been transferred from other locations. The fill consists of sandy clay and gravels. Materials are poorly sorted with fragments of claystone and concrete rubble. Colors range from pale to dark yellowish-brown.

2.4.1.2 Bedrock Geology

The Cretaceous Arapahoe Formation unconformably underlies the unconsolidated deposits in the Solar Ponds area. The Arapahoe Formation primarily consists of claystones and silty claystones. A subcropping sandstone has been mapped in the vicinity of Pond 207-C and along South Walnut Creek. A discussion of the depositional environment for the Arapahoe Formation may be found in Section 1.3.3.7 Regional Geology, in the sub-section entitled Upper Cretaceous Deposits. Figure 2-14 shows the bedrock geology. Figures 2-10 through 2-13 show the cross sections A through D, locations for which are shown in Figure 2-9.

The Bedrock Geology map shows three mappable units, one of which consists predominantly of sandstones, another of which consists predominantly of silty claystones and siltstones, and the last of which consists predominantly of claystones. The silty claystone unit is referred as such to coincide with the borehole spreadsheet bedrock lithology data in Appendix B. This mappable unit also includes all clayey siltstones and siltstones indicated below bedrock surface on original lithology logs. Siltstones are also likely to exist at bedrock surface inbetween borehole locations, interlayered with the silty claystones. All three mappable units are transitional and gradational and are distinguished only for the purpose of developing a conceptual understanding of the predominant bedrock lithologies. All delineations shown are subject to major revision, pending the results of the field investigation.

Arapahoe Sandstones

Sandstones in the Arapahoe Formation are poorly to moderately sorted, subangular to subrounded, clayey, silty, very fine-to medium-grained, with occasional occurrences of coarse-to conglomeratic. Trough and planar cross stratification are common sedimentary structures (EG&G, 1991i). Sandstones are lenticular in geometry and are interlayered with thin lenses of clay and silt.

The subcropping sandstones dip approximately 1.5 degrees to the east and are generally weathered within 30 to 40 feet of the base of the alluvium. The weathered section colors vary from pale orange to yellowish-gray and dark yellowish-orange. Unweathered sandstones are light to olive gray. Fractures have been noted in the weathered zone at depths of 5 feet to 14 feet.

A total of four sandstone intervals have been identified in the Arapahoe Formation in the Solar Ponds area, although some uncertainty exists as to whether the lower sand intervals occur as Arapahoe or Laramie sandstones. The Arapahoe Sandstone No. 1 unit outcrops and subcrops in

the Solar Pond area. Data contained in the borehole spreadsheet in Appendix B are summarized below for all sandstone intervals:

Sandstone Interval	Elevation (feet)	Thickness (feet)	Percent >200/230 Sieve Size (average)
1	5,946 - 5,973	12 - 29	47
2	5,928 - 5,883	4 - 13	28
3	5,872 - 5,854	5 - 8	4
4	5,868 - 5,803	2 - 13	35

As defined, the sandstone intervals contain abundant lenses of interlayered claystones and siltstones, keeping the actual percentage of sand relatively low.

Arapahoe Claystones/Silty Claystones

The Arapahoe claystones and silty claystones are massive and blocky, containing thin laminae and stringers of sands, silt, and lignite. The weathered zone in this material extends from 28 to 39 feet below the base of the alluvium. Weathered claystones range in color from pale yellowish brown to light olive gray and are moderately stained with iron oxides. Unweathered claystones are typically dark gray to yellowish gray.

Fractures have been encountered between 6 and 26 feet in depth, and are associated with ironstone concretions and calcareous deposits in the weathered zone. Vertical, subvertical, horizontal, and 45 degree fractures have been encountered in the unweathered zone at depths of 30 feet to over 100 feet. Many of the shallower fractures are stained with iron oxides or calcareous deposits, implying water movement (Rockwell International, 1988a).

Laramie Formation

The upper contact of the Laramie Formation is believed to occur at a depth of approximately 260 feet in the Solar Ponds area, although none of the boreholes drilled to date are believed to have encountered the Laramie (EG&G, 1991i, Geologic Cross-section G-G'). The estimated elevation for the contact is based on a correlation of the Laramie/Arapahoe contact established through the surficial geologic mapping effort to a nearby borehole (B304289) at a depth of 30 feet (EG&G, 1991i). The Upper Laramie, which consists mostly of silty claystones, siltstones, and some fine-grained sandstones, is estimated to be 460 feet thick at borehole B304289. The lower unit of the

Laramie Formation consists of coal beds and sandstones and is estimated to be 285 feet in thickness, based on correlations from earlier work by Wiemer.

Geologic Cross-sections

Geologic cross-section A-A' (Figure 2-10) trends south to north through the solar ponds area from well No. 3386 to well No. B208789 near North Walnut Creek. Topography is relatively flat in the Solar Ponds area except where artificial dikes have been built. Ground surface slopes steeply from an area north of the ponds through the protected zone and ITS towards North Walnut Creek. Quaternary alluvial thickness is approximately 10 feet in the pond area. The Arapahoe silty claystone subcrops throughout the section, except for a small lense of sandstone between ponds 207-A and 207-B South. Arapahoe claystones exist at both ends of the cross section.

Geologic cross-section B-B' (Figure 2-11) trends west to east south of the Solar Ponds area from well No. 2386 near Building 779 to well No. B213789 near South Walnut Creek. Quaternary alluvium thickens from five feet in the west to 10 feet east of the Solar Ponds area, then thins again down the slope towards South Walnut Creek. Arapahoe claystone subcrops in the west, and Arapahoe silty claystone subcrops in the area of Pond 207-A and Pond 207-B South. Sandstone No. 1 subcrops in the east near South Walnut Creek.

Geologic cross-section C-C' (Figure 2-12) trends west to east, south of Pond 207-C and through Pond 207-A and 207-B and continues south from well No. P209389 near Building 774 to well No. 2986 west of the perimeter security zone. Quaternary alluvium ranges in thickness from 7 to 15 feet. Top of the bedrock in the vicinity of Pond 207-C is the Arapahoe Sandstone No. 1. The sandstone is lenticular in shape with a maximum thickness of 22 feet and thins to 7 feet towards the east. The Arapahoe silty claystone is the top of bedrock beneath ponds 207-A and 207-B south. A gradational facies change from silty claystone to claystone occurs between wells 210289 and 207989. Changes in bedrock geology at depth can not be determined along this cross-section because all wells are shallower than 38 feet.

Geologic cross-section D-D' (Figure 2-13) trends west to east north of the solar ponds from well No. P219189 located near Building 774 to well No. B208189 to the east. Topography is hummocky along this cross section, rising northwest of Pond 207-C and then sloping downward towards the east. Quaternary alluvium is approximately 10 feet thick in the west until it pinches out at the Arapahoe Sandstone No. 1 bedrock outcrop located north of Pond 207-A. The thin veneer of

alluvium stretches eastward, where it thickens to 12 feet in the valley. The bedrock Arapahoe formation grades rapidly through facies changes from west to east. In general, the Arapahoe Sandstone No. 1 is lenticular in shape and outcrops in the vicinity of pond 207-C with a thickness of 30 feet, and thins easterly to 15 feet. Arapahoe Sandstone No. 2, 3, and 4 were encountered at depth. Additional information is needed to determine if these sandstones are laterally continuous. A large deposit of silty claystone is continuous eastward from well P209889 and gradationally changes to claystone.

Geomorphology

The land surface of the Solar Ponds area consists of an alluvial-covered pediment which has been deeply incised with east-trending streams. The streams have dissected both the alluvium and the underlying bedrock units along the drainages. It is conceivable that all sandstone intervals of the Arapahoe Formation have been exposed surficially within the corresponding elevations and locations along the drainages.

The extent to which exposed bedrock units can provide pathways to underlying strata is not fully known. However, outcropping and subcropping sandstones of the Arapahoe Formation are extensively interlayered with claystone and siltstone lenses, which serve as relatively impermeable barriers to downward migration of contaminants. The sandstones and claystones are lenticular and are likely to be laterally discontinuous.

2.4.2 Hydrology

2.4.2.1 Ground Water

Numerous investigations have focused on the geology and hydrogeology of the RFP including extensive drilling in the Solar Ponds area. The following discussion of site hydrogeology has taken into consideration the contents of the Solar Evaporation Pond Closure Plan (Rockwell International, 1988a), the results of the 1989 drilling program (performed by R.F. Weston), the Rocky Flats Summary of Field Investigations, the Rocky Flats Draft Final Geologic Characterization Report (EG&G, 1991i) and the Draft Phase I RFI/RI Work Plan for the Solar Evaporation Ponds (U.S. DOE, 1990b). Wells located within the Solar Ponds area are illustrated in Figure 2-15. Hydrologic data is included in Appendix C. Well completion records are included in Appendix B.

Generally, ground water in the Solar Ponds area flows east. Flow in the unconsolidated material generally follows the contact with the Arapahoe Formation claystones. The claystones have a low

hydraulic conductivity, on the order of 1×10^{-7} centimeters per second (cm/s), effectively constraining much of the flow within the uppermost hydrostratigraphic unit above the alluvial/bedrock unconformity (Table 2.1). The exception to this is the occurrence of ground water in the subcropping units beneath the alluvial material. In this situation, the ground water exists under unconfined conditions within the bedrock. In the Solar Ponds area, Arapahoe No. 1 Sandstone subcrops beneath Ponds 207-C and the northwest portion of Pond 207-A. The confining layers for the sandstones are the claystones and silty claystones of the Arapahoe Formation. The hydraulic conductivity of the Rocky Flats Alluvium and the Arapahoe No. 1 Sandstone is approximately 6×10^{-5} cm/s. The lower Arapahoe sandstones have a hydraulic conductivity of approximately 10^{-6} cm/s (Table 2.1).

Ground water flow in the Solar Ponds area is influenced by (1) recharge of precipitation, (2) leakage from the Solar Ponds and (3) drainage into the ITS. The amount of pumpage from the ITS is estimated at 4 million gallons per year. North of the Solar Ponds, the ITS drains ground water from the alluvial materials creating an area of unsaturation (Figure 2-16).

Upper Hydrostratigraphic Unit

In the upper hydrostratigraphic unit, the unconfined ground water table forms a smooth continuous surface sloping away from Pond 207-C through both the alluvial unit and the Arapahoe No. 1 Sandstone (Figure 2-12). In the vicinity of Pond 207-C, ground water flow appears to be in a westerly direction.

The potentiometric surface in surficial materials for first and third quarters 1990 are presented in Figures 2-16 and 2-17 for the Solar Ponds area. The first and third quarters represent the seasonal high and low flows, respectively. Ground water elevations for first and third quarters 1990 are presented in Tables 2.2 and 2.3. Well construction details are included in Table 2.4. Depth to water in alluvial materials ranges from 4 to 12 feet. Alluvial ground water enters the Solar Ponds area from the west and flows easterly (EG&G, 1991d).

Hydrographs were constructed for alluvial wells No. 3086, 2886, and 2686, located north of ponds 207-A and 207-B North, east of Pond 207-B North and south of 207-A, respectively. These wells show a similar trend in water level fluctuations with highs occurring in the summer months of May through August 1990 and 1991 and lows occurring in the winter months of November through February 1990 and 1991 (Figure 2-18).

Lower Hydrostratigraphic (Confined) Unit

Ground water flow within weathered bedrock is similar to that in surficial materials. First and third quarter potentiometric surface maps (Figures 2-19 and 2-20) show ground water flowing in an easterly direction. Water levels taken during 1990 indicate that the first and third quarters represent the seasonal high and low flows for the area (Tables 2.5 and 2.6). An area of unsaturated bedrock exists north of the Solar Ponds area, but is not extensive enough to prevent flow into North Walnut Creek (EG&G, 1991d). The hydraulic conductivity of the lower HSU (Arapahoe Claystone weathered and unweathered) ranges from 5.4×10^{-7} to 4×10^{-8} (Table 2.1).

Hydrographs were constructed for bedrock wells 2786 and P208889 (Figure 2-21). These graphs show that water levels fluctuated as much as 20 feet in well no. P208889 and 60 feet in well no. 2786. The cause of these water fluctuations is unclear, but may be due to poor well construction and/or inaccurate field measurements.

2.4.2.2 Surface Water

Surface water flow from the Solar Ponds area is toward North Walnut and South Walnut Creeks. A series of retention ponds known as the A-series ponds are located on North Walnut Creek, and a series of retention ponds known as the B-series ponds are located on South Walnut Creek (Figure 2-22). South Walnut Creek joins North Walnut Creek and an unnamed tributary coming from the landfill area, approximately 0.7 mile downstream of the eastern edge of the Plant security area, within the buffer zone. Walnut Creek then flows eastward approximately 1 mile into Great Western Reservoir.

North Walnut Creek

North Walnut Creek is an eastward flowing stream located north of the Solar Ponds area. Surface runoff patterns follow surface topography and indicate flow entering the drainage from the Solar Ponds area, the 700 Building Complex, the 300 Building Complex, and general surface runoff from the north and west sides of the Plant (Rockwell International, 1988a). Due to the surface drainage pattern, any releases from the 700 and 300 areas would flow into North Walnut Creek above the retention ponds in the drainage area located north of Pond 207-C (Rockwell International, 1988a).

The A-series ponds on North Walnut Creek are designated A-1, A-2, A-3, and A-4, from west to east. Currently, Ponds A-1 and A-2 are used only for spill control, and North Walnut Creek stream flow is diverted around them through an underground pipe. Previously (until 1980), Ponds A-1 and

A-2 were used for storage and evaporation of laundry water. Pond A-3 receives the North Walnut Creek stream flow and runoff from the northern portion of the Plant. Pond A-4 is designed for surface water control and for additional storage capacity for overflow from Pond A-3.

South Walnut Creek

South Walnut Creek is an eastward flowing stream located to the east of the Solar Ponds area. South Walnut Creek receives surface water runoff from the central portion of the Plant site. The Plant surface water drainage pattern indicates surface water drainage from the area south and southeast of the 207-B ponds flowing in a southeasterly direction toward South Walnut Creek. However, the drainage pattern also indicates runoff from the Mound and 903 Pad areas located to the south of the Solar Ponds would contribute to flow in South Walnut Creek (Rockwell International, 1988a).

The discussion of the 903 Pad, Mound, and East Trenches Areas Remedial Investigation Report attributes most of the surface water contamination in South Walnut Creek to the Mound and 903 Pad areas. For this reason, it is not felt that the Solar Ponds are contributing to South Walnut Creek contamination (Rockwell International, 1988a).

2.5 NATURE OF CONTAMINATION

A discussion of the nature of contaminants in the sources and affected media at the Solar Ponds is presented in this section. The primary emphasis is placed on characterizing both the current and historical composition of the pond liquids and sludges, and on characterizing the nature of contaminants in unsaturated soils near the site. Overall contamination at the Solar Ponds is characterized by assessing the distribution of compounds common to the sources, soil, ground water, surface water and air. Results from the multiple sampling efforts conducted on each of the sources and other media have been informally summarized and discussed in following subsections to enable an initial understanding of the type of contamination present in the Solar Ponds and media interactions occurring at the site.

As a result of this preliminary data review, it was found that the ponds are sources of nitrate, metals and radionuclides to underlying soils and ground water, and to surface water. Organic compounds were detected only infrequently in all media, and at low concentration, indicating organic compounds are of only minor significance to the overall characterization. Pond liquid and sludge contained elevated concentrations of metals and inorganics that are relatively immobile without the

presence of water to provide a transport mechanism. The ponds were high in nitrate, however, which was observed in all other media (except air) in a pattern indicating migration northward to the ITS and North Walnut Creek. Radionuclides were distributed in much the same pattern, although surface radiological studies indicate Pond 207-A to be a relatively unique source of surficial plutonium and americium. Other compounds showing a distribution pattern in soils are cyanide, chromium and lithium. Radionuclides present in pond liquid and sludge including americium-241, plutonium-239 and tritium are also evident in soils surrounding the Solar Ponds.

2.5.1 Sources -- Solar Evaporation Ponds

Wastes present in the five Solar Ponds differ based on their varied influent waste streams and their recent histories. Although all ponds have received facility process wastes in the past, recent maintenance, closure, and aquifer restoration activities have resulted in dissimilar waste characteristics in: Pond 207-A; Ponds 207-B North, 207-B Center, and 207-B South; and in Pond 207-C. Process waste water and sludge were removed from Pond 207-A as a part of closure activities in 1988, and the pond currently holds pumpback water from the ITS and incident precipitation. The process waste contents of Ponds 207-B North, Center, and South were removed during maintenance activities and the liners replaced in 1977. The linings of Ponds 207-B Center and 207-B South were removed, bagged, cemented and disposed of off-site. These ponds currently collect contaminated ground water from the ITS and Building 771 and 774 footing drains. The 207-B ponds were also used for storage and treatment by evaporation of sanitary effluent and treated water and backwash brine from the RO facility. Pond 207-C is the only pond that currently contains plant process wastes. In addition to these five active ponds, the Original Pond ceased to be used after 1956, and was filled and regraded in 1970. Contamination from this Original Pond may be present in soil beneath and surrounding Pond 207-C. As evidenced in aerial photographs, soil from the Original (clay-lined) Pond were possibly used in the construction of Pond 207-C (Rockwell International, 1988a).

To characterize waste composition in the Solar Ponds, numerous analyses of pond liquids and sludge have been conducted. Summaries of the laboratory results for pond liquids and sludges are presented in Tables 2.7 through 2.11 and supporting documentation provided in Appendix D. These tables contain a range of historical concentrations from the 1984-1988 time period, as well as recent sampling results from 1991. Although the historical results provide an indication of past waste characteristics, the 1991 data are considered more reliable as an indicator of current waste composition. Detailed laboratory data for the 1984-1988 time period are presented in Appendices 3 and 4

of the 1988 Solar Evaporation Ponds Closure Plan (Rockwell International, 1988a) while recent 1991 sampling results are presented in the Dames & Moore Summary Report (Dames & Moore, 1991). Visual descriptions of sludges were obtained from the Sampling and Analysis of Solar Pond Water and Sludge Final Report (Weston, Roy F., 1991).

2.5.1.1 Pond 207-A

A comparison of historical 1984-1988 and recent 1991 liquid and sludge sampling results for Pond 207-A reflects the removal of wastes from this pond in 1988 (Table 2.7). Historical results are similar to the characterization of Pond 207-C liquids and sludges, although the radionuclides and beryllium occurred at higher concentrations in Pond 207-A prior to waste removal. Acetone and tetrachloroethylene were detected in historical analyses of Pond 207-A sludge, but these common solvents were also detected in associated field blanks. Fluoranthene, di-n-butylphthalate and bis-(2-ethylhexyl)phthalate were also detected in Pond 207-A sludge during removal. Fluoranthene is a polynuclear aromatic hydrocarbon, and may be derived from the asphalt liner. The phthalate compounds are plasticizers. Pond 207-A currently collects only incident precipitation, although it has also been used to store ground water from the collection system. Concentrations of radionuclides, including americium, plutonium, uranium, and tritium, were greatly reduced after wastes were removed. Other characteristic waste stream constituents, such as nitrate and the alkali metals sodium and potassium, have decreased in concentration by several orders of magnitude since removal of pond liquids and sludge. In addition, other transition metals, such as chromium and nickel, are currently undetectable. Total cyanide occurs at relatively high concentrations, and high total dissolved solids content reflects the evaporative concentration of minor influent salts within the pond, as well as possible dissolution of remaining trace salts following waste removal. Chemical sludges, which historically contained high concentrations of radionuclides, transition metals, and salts, are no longer evident in Pond 207-A. Recent descriptions of the minor amount of solids present indicate that they are composed of primarily sediments and algae. As a result, sludges were not collected for analysis during the 1991 sampling effort.

Pond 207-A was originally designed in 1956 with ½-inch asphalt planking which was removed in 1963 and replaced with an asphaltic concrete liner. A sump is located in the northeast portion of the pond and the pond slopes toward the sump. No contaminant or leakage rate information is available on the pond. There was documented evidence in 1988 of pond liner leakage on the side slopes. The side slopes were relined in 1988 with an 1/8-inch thick rubberized crack sealing

material to minimize pond leakage. A surface water seep is observed near the northeast corner of the pond and is most likely a result of liner leakage in this vicinity.

2.5.1.2 Ponds 207-B North, Center, and South

Ponds 207-B North, Center, and South currently receive contaminated ground water from the ITS and from Building 771 and 774 footing drains. Pumped-back ground water is introduced into Pond 207-B North, and is subsequently transferred into Ponds 207-B Center and South. As a result of the storage and evaporation of ground water rather than waste water, the composition of Pond 207-B North, Center, and South liquid and sludge differs considerably from the contents of Ponds 207-A and 207-C. As shown in Tables 2.8, 2.9, and 2.10, Ponds 207-B North, Center, and South liquids contain nitrate as the dominant anion followed in abundance by chloride and sulfate. The dominant cations are the alkali metals sodium and potassium, while alkaline earth metals calcium and magnesium occur in lesser concentrations. The presence of calcium and magnesium in these pond liquids reflects the occurrence of these alkaline earth metals in local ground water. Radionuclide concentrations in the 207-B ponds are intermediate between the characteristics of Pond 207-A liquid, which is derived primarily from ground water pump-back and incident precipitation, and Pond 207-C liquid, which is representative of process wastewater. Transition metals characteristic of the process wastewater including cadmium, copper, chromium, and nickel, are absent or present only at relatively low concentrations in 207-B pond liquids. Historical analyses indicate the presence of methylene chloride in Pond 207-B North liquid, although this compound was also detected in field and laboratory blanks.

Visual descriptions of sludge from Ponds 207-B North, Center, and South indicate brown to green algae as the primary constituent. Analytical results indicate the presence of calcium and sodium salts of nitrate, chloride, and sulfate. Fluoride is absent. Radionuclides are present at relatively low levels, with the exception of uranium-234 and uranium-238 isotopes. These two naturally occurring uranium isotopes occur in 207-B pond sludges at concentrations intermediate between Pond 207-C sludge and the former 207-A sludge. These uranium isotopes may be derived from process wastes which have reached ground water, or may be naturally elevated in local ground water. Transition metals representative of process wastes, including chromium and copper, are present in Pond 207-B sludges, although cadmium and nickel are absent. A variety of semivolatile organic compounds were detected in the Pond 207-B North sludge composite sample. None of these compounds were verified as present in the individual samples comprising the composite, however.

The liners originally installed in 1960 for Pond 207-B North, Center and South consisted of asphalt planking. In 1960 and 1961, the asphalt planking was covered with asphaltic concrete. In 1977, the 207-B Center and South were removed, bagged, cemented and disposed of off-site. The 207-B North pond liner was not removed. The 207-B South pond received a 45 mil synthetic geomembrane and a leak detection system was installed. An underdrain system was reportedly installed on all three 207-B ponds, which was designed to collect ground water flow under the ponds and route it north along the ponds eastern edges, then discharge it to an open ditch north of Pond 207-B North. It is unknown if the underdrain system was installed.

No information regarding contaminants below the liner or estimated leakage flow rates are available on the 207-B Ponds. If the underdrain systems exist, they may collect ground water and leaking pond liquids and transport them via closed conduit to ditches north of the ponds. With the ITS in place and correctly operating, discharge to this ditch should be collected either as surface water in the gravel trench system or as ground water that has reinfiltrated below the surface.

2.5.1.3 Pond 207-C

The liquid and sludge contained within Pond 207-C is derived from the plant process waste water stream. Historical concentrations measured during the 1984-88 time period are consistent with recent 1991 sampling results, as summarized in Table 2.11. Recent results generally occur with the range of historical concentrations, where comparable data are available. Pond liquid characteristics include high nitrate and cyanide concentrations, although chloride, carbonate and sulfate predominate as major anions in solution. The alkali metals potassium and sodium occur as the dominant cations in solution. Total dissolved solids contents are approximately 40 percent, and have increased between the 1984-88 and 1991 time periods, consistent with the continued influx and evaporation of plant process wastes. Solution pH is alkaline, and the presence of sulfide suggests the possibility of reducing conditions. Radionuclides, including americium, plutonium, uranium, and tritium, are present within the pond liquids. Cadmium, chromium, copper, and nickel occur as the primary transition metals. The occurrence of radionuclides and transition metals as primarily dissolved constituents within the pond liquids is suspected since visual observations indicate that the liquid samples collected in 1991 were clear with no obvious suspended solids.

The organic compounds acetone, diazinon, and simazine have been reported in Pond 207-C liquids. Acetone was also detected in analytical blanks, and may reflect laboratory contamination. Diazinon and simazine are both pesticides. Diazinon is an insecticide and nematicide used to control soil,

crop and household pests, while simazine is a selective herbicide used to control annual grasses and broad leaf weeds.

Pond 207-C sludge was described in 1991 as a crystallized brownish-green solid with some sediment, ranging in thickness from 4 to 23 inches. The sludge consists primarily of sulfate, nitrate and fluoride salts of potassium and sodium. Other constituents occur as minor or trace constituents within these salts. Cyanide and phosphate occur at relatively high levels. Radionuclides are present in the sludge, but at concentrations several orders of magnitude lower than in the pond liquids. Transition metals, including cadmium, chromium, copper, iron and zinc, are also present. Nickel, which was present in Pond 207-C liquid, is absent in the sludge. No organic compounds were detected.

The liner of Pond 207-C is asphaltic concrete, and the original liner has been in use since 1970 when the pond was constructed. As evidenced in aerial photographs taken during the Pond 207-C construction, soil from the Original (clay-lined) Pond may have been used in construction of Pond 207-C. The pond is reported to be fitted with a leak detection system, although no information regarding leaks was available for use in this Work Plan. No contaminant data are available for soils underlying the liner. The integrity of the liner cannot be assessed until sludge and liquids are removed.

2.5.1.4 Contaminant Behavior

The chemical characteristics of wastes occurring within the Solar Ponds can be used to estimate their mobility in the environment and support the development of a conceptual model. Contaminant characteristics are discussed briefly in the following paragraphs to aid in understanding their affinity for different environmental media and their migration and transport behavior.

The alkali metal and alkaline earth elements, which include potassium, sodium, calcium and magnesium, occur abundantly in the natural environment. Lithium, which is also represented in the analyses of Solar Pond wastes, occurs in lesser natural abundance. These elements form the majority of dissolved cations both in wastewater and in ground and surface water solutions. At relatively high concentrations, such as those present in the Solar Ponds, they may precipitate from solution in association with the major anions as salts. Their relative concentrations may also influence soil characteristics through cation exchange and precipitation of caliche horizons. As

major constituents in natural and waste waters, the relative concentrations of alkali metal and alkaline earth elements may also be used to identify waters from different sources.

Chloride, sulfate, carbonate and bicarbonate form the majority of anionic constituents found in natural waters, and are also observed in major concentrations in the Solar Ponds. Nitrate and fluoride, which occur naturally as minor constituents in ground and surface waters, also occur as major components in solar evaporation pond wastes. These major anions can combine with trace metals in solution to form complex ions, and at high concentrations can also limit the solubility of major cations and trace metals through the formation of solid precipitates. Examples of natural precipitates include sodium and calcium sulfates and calcium carbonate, which commonly form alkali deposits in closed evaporative basins and caliche horizons in arid soils. Similar precipitates form the inorganic sludges found in the Solar Ponds. These major anions are relatively mobile in solution, and can act as tracers of contaminated water in natural systems.

The transition metals occur naturally as trace constituents in soil, ground water and surface water, but may also be significant environmental contaminants as a result of their widespread use and potential toxicity. Cadmium, chromium, copper and nickel occur in solar evaporation pond liquids and sludges. Their background dissolved concentrations in local ground water and surface water have not been formally established, but are likely to be in the 1 to 10 part per billion range (Hem, 1985). Background concentrations of these transition metals in Rocky Flats soil have recently been developed in the Final Background Geochemical Characterization Report (EG&G, 1990d). Mobility of these metals is limited by adsorption to clays, organic matter, and iron oxyhydroxides present in soils. Solubility is also limited by the formation of oxide or hydroxide solids under sulfate conditions. Migration of the transition metals is therefore limited in the subsurface environment. Transport in association with particulates as suspended or bed load solids in surface water or as dust in air is common.

Radionuclides present in the Solar Ponds include both naturally occurring and man-made isotopes. These elements may be of concern due to both their radioactivity and chemical toxicity. The uranium isotopes occur naturally in soils and sediments, and exist in recoverable quantities near the Rocky Flats Plant. Their mobility is variable and is based primarily on environmental oxidation-reduction and pH conditions. Tritium is formed naturally by solar radiation in the upper atmosphere, although testing of nuclear weapons has far overshadowed this natural contribution to background activities. Tritium substitutes for hydrogen in the water molecule, and therefore acts

as a conservative tracer when present in liquid wastes and introduced to the environment. Plutonium and americium are transuranic actinide elements, and do not occur naturally in the environment. As with tritium, however, sensitive analytical techniques allow measurement of background concentrations of these elements which result from atmospheric testing of nuclear weapons. Plutonium and americium both form insoluble hydroxide and oxide solids under neutral to basic pH conditions, rendering their mobility limited in the subsurface. Similar to the transition metals, however, plutonium and americium may be transported in association with particulates in surface water or air, or possibly as colloids in ground water. In addition, the presence of high concentrations of complexing anions may act to increase solubility.

Gross alpha and gross beta are composite measurements of all natural and anthropogenic radioactive constituents which decay by alpha and beta particle emission, respectively. Although useful for determining the potential exposure to a radioactive source, these measurements have limited application in evaluating contaminant state or mobility. They may provide an effective screening tool in estimating the presence of specific radionuclides of interest, and in identifying specific areas requiring detailed analysis.

2.5.1.5 Other Sources

Other potential sources of contamination include the Original Process Waste Lines (OPWL), which exist extensively in an underground network adjacent to the Solar Ponds. A map showing the presence of the OPWL in the Solar Ponds area is included in Appendix A. The OPWL network is contained within the separate Operable Unit 9 (OU9) and will be investigated separately. However, extensive coordination will be required in view of the overlapping nature of the OU9 and OU4.

2.5.2 Soils

The nature of contaminants in soils near the Solar Ponds were assessed using data obtained from three previous sampling programs conducted in 1986, 1987, and 1989. The location of all soil borings considered in this assessment are shown in Figure 2-23, where the soil sampling programs are differentiated by color.

The 1986 Field Investigation included split-spoon sampling of alluvium, bedrock and the bedrock/alluvium contact in five boreholes. These five boreholes are shown in red on Figure 2-23 and were later completed as Wells 1886, 2086, 2286, 2586 and 2786. The procedures followed during the 1986 sampling program are described in the Draft Work Plan, Geological and Hydrological Site

Characterization. Sample analysis results for the 1986 soil borings are contained in Appendix C of the Solar Ponds Closure Plan (Rockwell International, 1988a).

The 1987 field program included collection of soil samples from 16 boreholes, SP01-87 through SP16-87, shown in green on Figure 2-23. Two of the boreholes were completed as monitoring wells; Borehole SP08-87 was completed as Well 3987, and SP16-87 as Well 5687. The procedures followed during the 1987 field investigation are described in the Comprehensive Environmental Assessment and Response Program (CEARP), Phase 2, Rocky Flats Plant, Installation Generic Monitoring Plan (Rockwell International, 1988a). Sample analysis results for the 1987 soil borings are contained in Appendix C of the Solar Ponds Closure Plan (Rockwell International, 1988a).

The 1989 soil investigation program at the Solar Ponds included sample collection from 20 boreholes, later completed as wells. The 1989 soil borings are shown in purple on Figure 2-23 and are denoted with the prefix P, the well number, and the 89 extension. The "P" series wells not shown on Figure 2-23 were not included in the soils assessment for this Work Plan.

The 1989 data were used not only to determine what contaminants were present near the Solar Ponds, but to conduct initial comparisons to data from the pond liquid and sludge. The comparisons allowed initial determinations to be made regarding the nature of contamination in the pond liquid and sludge and probable media relationships. Identified data gaps and the need to further evaluate media interactions will guide development of the field sampling plan presented in Section 7.0 of this Work Plan. The 1989 data were also used to reassess earlier conclusions made using 1986 and 1987 sample analysis results.

During the 1989 soil investigation, two to four soil samples were collected from each boring and analyzed for metals and inorganics. In addition, water samples were collected from those borings where ground water was encountered. Constituents detected in samples from the 1989 soil borings are presented in Table 2.12. Metals and inorganics were analyzed in all soil samples submitted for analysis, although radiological analyses were conducted on samples from only seven of the twenty 1989 borings. Organics were only analyzed in ground water samples from the 1989 program.

Sample analysis results were evaluated using statistically based background soil/vadose characteristics that are presented in the Final Background Geochemical Characterization Report (EG&G, 1990d). This background evaluation, conducted in 1989, involved a comprehensive collection of

stream sediments, surficial alluvial and colluvial sediments, and bedrock material from uncontaminated areas of the buffer zone. This collection of samples includes nine stream sediment samples from nine locations, 70 alluvial sediment samples from nine locations, 28 colluvial sediment samples from nine locations, and 20 weathered bedrock samples from the nine colluvial sample locations. Four of the nine alluvial borings and four of the nine colluvial borings were drilled in the Northern Buffer Zone, and summary statistics were calculated for those data to independently evaluate North Rocky Flats.

Detailed statistical methods described in the Background Geochemical Characterization Report (EG&G, 1990d) were then applied to the observed concentrations soil data and statistical summaries were generated. Statistical summaries were prepared using the background samples in alluvial materials, and the samples from colluvial, weathered claystone and weathered sandstone. Summaries were prepared for North Rocky Flats, South Rocky Flats, and Rocky Flats as a whole. These statistical methods were used to generate a range of upper values for individual parameters. In this case, this upper range value was designated the upper tolerance limit. Concentrations of chemical parameters in soil boring samples were compared to these upper tolerance limits and evaluated more closely than results below the upper tolerance limit.

Because OU4 is located in the northeastern portion of the Rocky Flats Plant, data from the Solar Ponds and surrounding area were evaluated using the statistical summaries for the Rocky Flats North alluvial and weathered bedrock materials. Statistical summaries for Rocky Flats as a whole were also used for those compounds not calculated in the Rocky Flats North summaries. These statistical summaries are presented in Appendix E of this Work Plan.

The 1989 soil/vadose zone investigation supersedes background soil information collected in a 1986 study. In the 1986 Background Soil Investigation, limited samples were collected, and the establishment of a background value for a chemical parameter was taken as the upper range of values from those samples. The 1989 soil/vadose zone soil investigation was selected for use in evaluating soil data because it is statistically based and derived from a much larger data set than the 1986 investigation.

Selected analytical results from 1989 soil samples are summarized in Tables 2.13 and 2.14, and are compared on a relative basis to historical soil data presented in Appendix C of the Solar Evaporation Ponds Closure Plan (Rockwell International, 1988a). Data for these soil sampling programs were

compared to established background values to evaluate potential anthropogenic contributions of naturally occurring elements, spatial trends were also investigated to determine possible source areas. Particular attention was paid to contaminants detected in pond liquids and sludges.

Major Anions

Nitrate concentrations in soil samples near the Solar Ponds exhibit strong relationships in both horizontal distance from the ponds and depth profile. Nitrate concentrations in soil are depicted in Figures 2-24 and 2-25, which presents soil analytical results for the sum of nitrate plus nitrite constituents as nitrogen. A review of samples for which both nitrate and nitrate plus nitrite data are available reveals that nitrate is the predominant nitrogen form present. Nitrate was detected in nearly all soil samples from near the Solar Ponds. Many of those borings located within approximately 50 feet of the pond perimeters exhibited relatively higher nitrate concentrations in near-surface samples. Borings located greater than 50 feet away tended to exhibit a nitrate contamination profile that increased with depth, appearing highest in vadose zone soils near the water table. The highest nitrate concentrations, greater than 1000 ppm in soils, were detected north and northeast and downgradient of Pond 207-B North in borings located adjacent to the inner boundary of the PSZ. This area corresponds to the location of ground water seeps which contain relatively high nitrate concentrations. A 1986 boring, located approximately 600 feet northeast of the borings containing highest nitrate, had concentrations less than 50 ppm.

Nitrate was detected in only a small percentage of background alluvial and weathered bedrock soil samples, and upper tolerance levels were not calculated for nitrate or nitrate/nitrite. The average nitrate concentration detected in background alluvial and weathered bedrock samples were less than 1 ppm. Concentrations detected in the vicinity of the Solar Ponds were as much as 3000 times greater than mean background concentrations.

Sludge and liquid samples from the Solar Ponds were found to contain relatively high nitrate concentrations. Releases from those ponds in the form of seepage and windblown aerosols, are the most likely sources of nitrate in the soil. The nitrate profile in soils is consistent with the behavioral geochemical characteristics of nitrate. Nitrate typically remains in solution as it infiltrates through the vadose zone and enters ground water. In areas of infiltration, wastewater, ground water seepage, or near the capillary fringe, relatively high soil nitrate concentrations would be anticipated due to presence of moisture containing high dissolved nitrate.

From a historical perspective, soil nitrate concentrations in the early 1970s were an order of magnitude higher than currently observed, and generally located near the surface (Rockwell International, 1988a). It is believed that the ITS has lowered the water table and allowed leaching of the near surface soils by precipitation.

Cyanide was detected in two 1987 borings located near the ponds. The highest cyanide concentrations were 8.7 ppm in the upper soils from a boring located between Pond 207-A and Pond 207-B South. Cyanide was detected at lower concentrations in two samples located north of Pond 207-B North and was below detection limit in all other 1986 and 1987 soil samples. Cyanide was not analyzed in 1989 samples. Pond 207-C and 207-A liquids contain high cyanide concentrations. The presence of cyanide in soils near Pond 207-A is probably indicative of release from this pond.

Sulfide, the only other major anion analyzed in soils was generally below detection limit, exhibited no distinct patterns indicative of solar evaporation pond contamination. The absence of sulfide also suggests the absence of strongly reducing conditions in soil.

Physical Parameters

Measurements of pH taken on all soil samples indicate a relatively neutral condition in the Solar Ponds area soil. Measurements of pH in ground water were similarly neutral. Mostly neutral pH measurements were obtained from water samples in the 1989 program. One slightly alkaline sample was collected from ground water in an area northeast of the ponds. This sample contained soil and ground water contaminants similar to pond liquids. Surface water pH measurements in the area were generally neutral.

Transition Metals

Cadmium was below detection limits in most soil samples from the area. One relatively high concentration was detected in a sample collected at a depth of 3 to 9 feet near the ponds, but no overall trends were observed. Cadmium concentrations in sludge ranged from 30 to over 10,000 ppm, but do not appear to have been released to surrounding soil.

Chromium in pond liquid and sludge samples were detected at relatively high concentrations of up to 17 ppm in liquid and up to 20,000 ppm in sludge. Chromium was detected in isolated soil samples, and may indicate mobility of chromium in the vicinity of the ponds. Chromium was present at 10 feet and greater in samples from two 1987 borings located near the 207-B series

ponds, at concentrations nearly 40 times that which is indicated as background. Another sample from the 3 to 9 foot depth contained chromium at over 4 times background. These isolated occurrences suggest possible release of chromium in pond wastes but are not indicative of wide-spread mobility of chromium.

Copper was generally detected at concentrations similar to those detected in background samples. Copper was detected at one to four times greater than background in several 1989 borings located south and east of the Solar Ponds, and in two 1987 borings located on the pond perimeters. The highest concentration, 73.6 ppm was detected at 12 to 18 feet below the surface in a boring approximately 150 feet east of Pond 207-B Center. There is no apparent correlation between copper distribution in soil and copper in Solar Pond sludge and liquids.

Nickel was detected sporadically in samples throughout the Solar Pond area. The highest nickel content was 6 times the levels from background samples. Nickel was detected in liquids from all ponds with highest concentrations in Ponds 207-A and 207-C, but soil samples located on the perimeter of the pond were all below background. The low level nickel concentrations in the vicinity may be related to Solar Pond wastes.

Arsenic was detected in several samples from the 1987 and 1989 programs, at values ranging from 1 to approximately 14 times the concentrations indicated as representative of background conditions. The distribution of arsenic in these soil borings shows no direct correlation with the ponds, and may be attributable to geochemical variation in soils. The highest concentrations were from bedrock samples at a depth of approximately 20 feet. Liquid samples from the ponds contain less than 0.16 ppm arsenic and are not considered significant sources of soil contamination.

Concentrations of aluminum in soils ranged from one to three times the concentrations indicated as background for alluvial soils in the Rocky Flats vicinity. Aluminum was detected at low concentration in shallow soil samples in several borings within 100 feet of pond perimeters, suggesting that elevated aluminum in soils may be related to Solar Pond contamination. However, recent and historical data for sludge collected from the ponds indicated the presence of aluminum concentrations similar to or lower than those observed in alluvial soils. Release of these sludges should not result in increasing aluminum concentrations in soil.

Several surface samples from borings east and south of the Solar Ponds contained low concentrations of mercury, but mercury was not detected in samples collected closer to the ponds. Low level mercury is not attributed to Solar Pond contamination.

Other metals, including lead, selenium, thallium and zinc were either detected well below background, or were of relatively low concentration and showed no apparent relationship to Solar Pond liquids and sludges.

Alkali and Alkaline Earth Elements

Alkali metal and alkaline earth elements, including potassium, sodium, calcium and magnesium were detected in the vicinity of the Solar Ponds at levels higher than in buffer zone soils. Their widespread occurrence in this area is likely due to precipitation as salts from Solar Pond liquids released through seepage or as aerosols. Because these elements are relatively soluble and form significant percentages of the pond wastes, they may act as tracers of pond contamination, similar to nitrate. Potassium levels in soils were less than three times greater than levels indicated as background. Sodium content, which may be indicative of pond liquid metal precipitation was highest in samples collected above 10 feet in the Original Pond area, and northeast of the ponds. Sodium content was elevated only at 2 to 3 times values detected in background samples. Calcium content in Solar Ponds area soils was as much as 20 times greater than levels in background alluvial and background soils. The highest calcium levels occurred in soils less than 13 feet deep in soils east of the Solar Ponds. Similarly, magnesium was found in soil samples east of the ponds. Magnesium was found in subsurface soils at levels less than three times the levels detected in background soils.

Lithium was detected in sludge from Pond 207-C at a maximum concentration of 43 ppm. In liquid, lithium was detected at highest concentrations in the 207-B ponds. Soil samples located adjacent to the 207-B ponds did not contain lithium above detection limits. Near surface samples south of Pond 207-C and in the Original Pond location did contain low levels of lithium, although they were only 2 to 3 times that which is indicated as background. There may be a relationship between lithium and the Original Pond based on these data.

Beryllium was detected at levels only 2 times greater than values indicated as background, and at various depths. Beryllium was detected at a maximum concentration of 1970 ppm in Pond 207-A sludge, although no clear relationship has been observed due to the low level, sporadic distribution in soils.

Barium was generally detected at concentrations of less than 2 to 3 times values indicated as background, with one exception. One elevated sample of 11,600 ug/g barium is approximately 150 times what is considered indicative of background. There is no apparent relationship to barium and Solar Pond contamination. Barium was generally undetectable in the Solar Pond sludge and liquid.

Radionuclides

Samples from seven borings in the 1989 program were submitted for radiochemistry analyses. A summary of the results of these analyses are in Table 2.14. Historical radiochemistry data are summarized in Table 2.15. Each data set was evaluated using the background geochemical report as a basis for comparison.

Tritium was detected in many samples near the pond perimeters, and in borings located east and northeast of the ponds. The tritium distribution patterns approximate those exhibited by nitrate. The highest concentrations of tritium are at depth, many from vadose zone samples at or near the water table. Tritium is found to have a positive correlation with nitrate, with many of the borings containing high nitrate also containing elevated tritium. The highest tritium concentration was nearly 100 times the value detected in buffer zone soils, but in general tritium concentrations were 3 to 5 times greater than tritium in buffer zone soils. Tritium is relatively mobile in vadose zone soils, as tritium substitutes for hydrogen in water molecules.

Distribution of gross alpha, which may provide indication of the presence of other radioisotopes, such as plutonium -239 or americium -241, did not indicate presence of alpha emitting radionuclides. Values of gross alpha from Solar Pond area soils were generally below the values indicated as background in the Final Background Geochemical Characterization Report (EG&G, 1990d). Only a few samples revealed gross alpha in excess of background. Similarly, gross beta values, which may indicate the presence of strontium-90 or cobalt -60 for example, were not at levels exceeding those in background samples.

Uranium-233 and -234 were detected at 1 to 3 times higher than background samples. The higher levels were typically in soil intervals at depth, but surficial samples near Pond 207-C also contained uranium -233 and -234. The Solar Ponds may contribute to uranium levels in the area, although contributions may also be received from other natural sources.

Uranium-238 was detected at a similar ratio to background samples, usually at 1 to 3 times higher. Levels were generally higher with depth, an observation that generally agrees with the background sample findings. Uranium -238 in background weathered bedrock samples was generally higher than in alluvial materials.

Plutonium-239 is widespread through the Solar Ponds area, and is detected almost exclusively in near-surface samples. Plutonium was detected in historical samples on the pond perimeters, in areas west and north of Pond 207-C, and northeast of Pond 207-B North. The highest levels were measured near Pond 207-C, near the Original Pond location. With these data, it is not evident that plutonium in this area is related solely to the Solar Ponds, or to widespread surficial plutonium in this portion of the Rocky Flats Plant. Plutonium-239 levels ranged from 5 to nearly 1000 times levels detected in background samples. The highest levels were near the Original Pond.

Americium-241, a decay product of plutonium, is distributed at the site much like plutonium. Americium-241 is found typically in the upper soil samples and is relatively widespread in the vicinity of the ponds. The higher surficial levels of americium were located in the vicinity of Pond 207-C, at activities from 25 to over 150 times greater than levels detected in background samples.

In June 1990, surficial soil sampling was conducted near Building 788 and Pond 207-A in response to increased plutonium concentration in air in this vicinity. Three soil samples collected June 20, 1990 and analyzed for plutonium and americium found an approximate americium to plutonium activity ratio of 2 to 1. Plutonium and americium levels were well above what was detected in soil samples from previous soil sampling programs. Maximum values obtained were 934 pCi/g americium and 438 pCi/g plutonium (see Appendix E). The data are currently undergoing validation, thus validated results were not available for use in this Work Plan. A copy of the telephone log documenting early conclusions of this study is provided in Appendix E.

The conclusions of the surficial sampling program near Pond 207-A prompted the conduct of a Field Instrument for Detection of Low-Energy Radiation (FIDLER) survey of the Solar Ponds embankments. The instrument counts alpha particle emission from surface soils and was used to determine distribution of the alpha emitters such as plutonium and americium. The FIDLER survey was conducted in August 1990, and readings from two FIDLER instruments were used to allow comparison of results. One-minute integrated counts were collected at background locations and on pond perimeters. Readings were taken at nearly 170 locations around the ponds. The survey found the

area of Building 788 and Pond 207-A embankments to have elevated alpha counts relative to the Pond 207-C and 207-B series embankments; an indication of higher radionuclide content in Pond 207-A than the other ponds. A relatively isolated area between and east of Ponds 207-B Center and 207-B South also had elevated readings. A copy of the results from this FIDLER survey are in Appendix E.

Organics

No organic analyses are contained in the RFEDs database for soil samples from the 1989 program. Historically, analytical data for core samples collected in 1986 indicated the presence of low concentrations of methylene chloride, chloroform, acetone, 2-butanone, 1,1,-dichloroethane, 1,1,1-trichloroethane, trichloroethylene, toluene, and total xylene. In most cases, volatile organic compounds are at estimated concentrations below the positive quantitation limit and/or are present in the laboratory blanks. No analyses for laboratory blanks were included with the volatile organic analytical results for the 1987 samples, in which methylene chloride, chloroform and 2-butanone were detected. The volatile organics were generally near or below detection limits. Organic compounds were not detected at elevated concentrations in pond liquid and sludge samples, and organic compounds at the Solar Ponds are of less significance than the inorganics and radionuclides.

2.5.3 Ground Water

Ground water in the vicinity of the Solar Ponds is monitored within the site-wide RCRA Ground Water Monitoring Program. Quarterly sampling is conducted under the program. Most of the RCRA ground water monitor wells correspond to the 1989 soil boreholes, as each borehole was later completed as a well. Data collected during the March 1990 sampling period or as close to that month as possible, were evaluated in this work plan to determine possible relationships to Solar Pond liquid, sludge and surrounding soil.

In addition to RCRA ground water program wells, ground water data collected during the 1989 soil boring program is considered on a relative basis. These data are presented in the RFEDs data base as GSEP series data, and are in Appendix F.

2.5.3.1 Alluvial Ground Water Quality

The alluvial ground water wells are indicated with an open circle on Figure 2-15. Ground water quality data for alluvial wells is presented in Appendix F and was taken from the 1990 Annual RCRA Ground Water Monitoring Report (EG&G, 1991d).

Distribution of nitrate in alluvial ground water generally correlates with distributions in soil. Figure 2-26 shows the nitrate/nitrite isoconcentration contours that were presented in the RCRA Ground Water Monitoring Report for First Quarter 1990. The combined nitrate plus nitrite analytical results are considered indicative of primarily nitrate in solution. The figure indicates highest nitrate concentrations to occur east of Ponds 207-B North and 207-B Center, whereas vadose zone soil data indicate the highest nitrate levels in areas are north and northeast of Pond 207-B North.

Volatile organic compounds were detected in alluvial ground water in an isolated area west of Pond 207-C. Soil from the borings drilled to construct these wells were not analyzed for volatile organics, but the source of these organic compounds is perhaps associated with the Original Pond, or from other upgradient sources.

Evidence of low levels of americium and strontium-90 are indicated by alluvial ground water results. Activities are relatively low and near detection limits. Strontium metal was present in several alluvial wells located east of the ponds, but the compound is not observed to be widespread in the alluvial ground water system.

Total dissolved solids were highest in the alluvial system east of the 207-B ponds in a pattern consistent with the nitrate distribution in vadose zone soil.

2.5.3.2 Bedrock Ground Water Quality

Ground water quality in the weathered bedrock system is characterized using the RCRA Ground Water Monitoring Program First Quarter 1990 Data (EG&G, 1991d). As with the alluvial water quality discussion, data obtained from water samples in the 1989 soil boring program were also considered on a relative basis. These data are included in Appendix F.

Nitrate in the weathered bedrock system is indicative of Solar Pond contamination due to its mobility through soils to ground water. The nitrate/nitrite distribution in weathered bedrock is

indicated on Figure 2-27. As with the alluvial distribution figure for nitrate, the bedrock distribution correlates with the distribution in soils. High nitrate is found throughout the soil column in samples near the perimeters of the ponds with the highest concentrations being north and northeast of the ponds. Nitrate distribution follows the ground water flow path to the northeast.

Bedrock ground water nitrate isopleths depicted in Figure 2-27 were taken directly from the RCRA Annual Ground Water Monitoring Report for 1990. Current interpretations suggest the presence of elevated nitrate concentrations in a continuous plume extending from the ponds area toward the northeast.

Lithium was detected in several bedrock wells, with highest concentrations being north and northeast of the ponds. Tritium and strontium were detected throughout the weathered bedrock monitoring network, again increasing in concentration in the northeast, as well as exhibiting moderately high levels east of the ponds. Gross alpha was detected in a similar distribution pattern, at concentrations as much as 8 times greater than the 15 pCi/l maximum contaminant level for gross alpha in drinking water.

2.5.4 Surface Water Quality

Surface water sampling in the Solar Ponds area is summarized in the Solar Pond Interceptor Trench Study Ground Water Management Study Zero-Offsite Water Discharge (ASI, 1991).

Surface water in the northern vicinity of the Solar Ponds drains northward to North Walnut Creek, but is intercepted by the uncapped drains within the ITS. Surface water captured in the ITS mixes with intercepted ground water and is pumped back to Pond 207-B North. Concentrations in Pond 207-B North liquid vary with water fluctuation, evaporation rates, and other factors. Surface water monitoring stations are located both within the interceptor trench system and in the area north of the ponds.

Selected parameters detected in surface water from these stations are summarized on Figures 2-28 and 2-29. A number of parameters occur in surface water, in somewhat similar patterns. Nitrate and total dissolved solids were detected in highest concentrations from three sampling locations located north of Ponds 207-A and the 207-B ponds. Sampling stations north of Building 774 and Pond 207-C contained much lower concentrations of these parameters. Radionuclides plutonium-238 and americium -241 were detected in surface water throughout the area, the highest from surface

water station 89 located between and immediately north of Ponds 207-A and 207-B North. Volatile organic compounds, primarily acetone, were detected in surface water samples located near Building 774, and from samples in and near the West Collector. Surface water in the area east of the ITS does not appear to be impacted by these contaminants (ASI, 1991).

Surface water samples collected downgradient of the ITS, in North Walnut Creek and the A-series ponds on North Walnut Creek in August 1986, July 1987 and November 1987, were analyzed for the Hazardous Substance List (HSL) volatile organics, semivolatiles, pesticides/PCBs, major inorganic ions, metals and radionuclides (Rockwell International, 1988a). The A-series ponds were constructed on North Walnut Creek to control surface water flow off the RFP site. Those analytes exceeding detection limits include manganese, thallium, iron, and total dissolved solids (TDS). The highest concentration of manganese, thallium, iron, and total dissolved solids occurs in samples collected from Pond A-2, and may reflect residual contaminants from past usage to store laundry effluents (Rockwell International, 1988a). In samples collected from Pond A-3, TDS and manganese exceeded the water quality criteria. However, discharges from Pond A-3 are in compliance with the conditions listed in the Plant's NPDES permit. Furthermore, at the most downgradient surface water station, SW-3 at Indiana Street (not shown on figures), all analyte concentrations are below the surface water quality criteria.

In the Solar Evaporation Ponds Closure Plan (Rockwell International, 1988a), it was concluded that degradation of surface water quality in North Walnut Creek is due, in part, to recharge by alluvial ground water in the vicinity of the Solar Ponds. However, containment of the flow by Pond A-3 and Pond A-4 with attendant reduction in analyte concentrations by natural processes, renders the quality of surface water leaving the RFP site acceptable with respect to the water quality criteria (Rockwell International, 1988a).

2.5.5 Air

Air monitoring data collected by Radioactive Ambient Air Monitoring Program (RAAMP) stations in the Solar Ponds area are contained in Appendix G. A map showing the locations of the RAAMPs is included with the data. Such data are collected on a routine basis and additional, more current data will be available for review as part of the first planning task of the Phase I RFI/RI program.

The highest plutonium concentrations have been detected from Stations 1, 5 and 8B with maximum average monthly values of 0.003197 pCi/m³ for Station 1, 0.001389 pCi/m³ for Station 5, and 0.000708 for 8B, based on the data in Appendix G.

2.6 SITE CONCEPTUAL MODEL

The site conceptual model is intended to describe known and suspected sources of contamination, types of contamination, affected media, contaminant migration pathways, and environmental receptors. The site conceptual model is used to assist in identifying sampling needs to obtain information for evaluating risks to human health and potential remedial alternatives. The site conceptual model is developed and based on the information presented previously and includes potential contaminant migration pathways from the Solar Ponds to other media or receptors. The conceptual model is used to express current understanding of the nature and distribution of contaminants and potential contaminant pathways. Thus, the conceptual model can be used to help guide the RFI/RI investigations by testing current understandings.

The Phase I RFI/RI, in accordance with the IAG, focuses on sources and soils (e.g., Solar Ponds liquids and sludges; liner material; surficial soils; and vadose zone materials) and, therefore, so does the conceptual model. However, to facilitate integration with the Phase II investigations, ground water, air, and biota are included in this conceptual model, even though they will be the primary focus of Phase II.

The primary source of contaminants in the Solar Ponds area are the process fluids piped to the ponds for storage and treatment. Fluids have been contained in the ponds since approximately 1953, and include the recent introduction of both treated sanitary wastewaters from the plant and ground water pumped back from the ITS. The liquids, sludges, and lining materials in the ponds are potential contaminant sources to the subsurface. Additional primary sources of contaminants in the Solar Ponds area include potential leakage from existing and abandoned pipelines, drainage from footing drains from nearby buildings, and the Original Pond in the vicinity of existing Pond 207-C.

The conceptual model is shown on Figure 2-30. The potentially affected media and contaminated migration pathways that are included in this Phase I RFI/RI Work Plan include:

- Surficial soils
- Subsurface soils of the vadose zone.

Not part of this Phase I RFI/RI Work Plan, but related as both sources and potential receptors, include process waste lines, surface water, ground water, and air. The potential interrelationships between those modes of contaminant transport and receptors are illustrated on Figure 2-31. Because they are related, a conceptual understanding of these transport modes is necessary to most effectively plan further investigations.

2.6.1 Pond Liquids and Sludges

The ponds are conceptualized as mixing vessels, open to the atmosphere, in which solar radiation increases the solids concentration to form a sludge of the mixture. The sludges are composed of crystalline wastes, algae and sediments. The liquids and sludges in the ponds are undergoing changes in chemistry through the mixture of different cations, anions, and suspended solids. These reactions are complicated by the evaporative process combined with periodic dilution by rainfall and snowmelt, volatilization, photochemical reactions, microbiological activity, and possible reaction with liner materials. These processes can transform both the liquid and solid chemical composition into additional dissolved and complexed chemical constituents that can potentially be transported through infiltration and percolation into the vadose zone and ground water system.

2.6.2 Surficial Soils

Soils in the vicinity of the Solar Ponds are potentially contaminated with aerosols from the ponds, contaminants from ground water seeps, and from other spatially related sources such as process waste lines that may not be distinguishable from the Solar Ponds. Contaminants in the surficial soils may be transported:

- Into the vadose zone and, ultimately, into the ground water system via infiltration of precipitation and/or leakage from the Solar Ponds
- Laterally, via surface runoff or as airborne fugitive dust.

The principle parameters that control the aforementioned transport are the chemical nature of the contaminants, particulate size and occurrence, and rate of infiltration from precipitation and/or leakage from the Solar Ponds.

2.6.3 Vadose Zone

The vadose zone is defined as the unsaturated subsurface depth interval from the surface to the water table, including perched ground water zones and multiple geologic/lithologic units. It is

commonly termed the unsaturated zone but in the Solar Ponds Area, there may be perched ground water intervals and leakage zones that are saturated. Descriptions of the saturated status of soils in the Solar Ponds area indicate multiple saturated intervals within 25 feet of the ground surface which, in some cases, may be indicative of perched water. Exchanges between the vadose zone and ground water involve both the maximum and minimum depth interval of the fluctuating ground water level and the associated capillary fringe. The capillary fringe is a fluctuating depth interval of partial saturation that extends upward from the water table and it is included as part of the vadose zone. Perched water may flow laterally through overlying impermeable strata, and discharge at the surface as ground water seeps.

Both the Solar Ponds and surface soils are similar through their exposure to atmospheric physio-chemical conditions. These conditions can change abruptly in isolated sludges or in subsurface soils. Approximately one-third of the surface is covered by ponds, buildings, and roads that restrict the movement of oxygen from the atmosphere into the subsurface. Leakage from the ponds contains nutrients for microbial activity. The changes associated with processes such as microbial activity can affect the fate and transport of contaminants in the vadose zone. For example, the fate and transport of both transition metals and radionuclides are strongly dependent on pH and oxidation reduction potential (Eh) (Dragun, 1988) in both vadose zone water and ground water.

The ionic state of metals and radionuclides and the particle size of materials to which they are sorbed affects their transport in the subsurface. Laboratory and field investigations involving organic and inorganic ions indicate that the cationic ions (positively charged ions) and ionic complexes are removed or exchanged from solution much more effectively than anions (negatively charged ions). Also, recent research suggests that colloidal material is also a significant transport mechanism in the subsurface (Penrose et al., 1990).

2.6.4 Unconfined Ground Water System

Ground water is believed to be present in the Rocky Flats Alluvium, colluvium, and subcropping sandstones in the vicinity of the Solar Ponds under unconfined conditions. Depths to ground water are expected to vary from 0 to 25 feet below ground surface depending on location, antecedent precipitation, and time of year. Ground water flow is primarily toward the northeast.

Recharge to the unconfined ground water system in the vicinity of the Solar Ponds is expected to be primarily: (1) from infiltrating precipitation, and (2) leakage from the Solar Ponds. It is

expected that contaminants in the liquids leaking from the pond(s) are carried downward into the vadose zone. Less mobile contaminants may become bound to soils, while soluble components will be transported to the water table. Contaminants that have spread laterally in the vadose zone are subject to subsequent downward migration from the leaching affect of infiltrating precipitation.

2.6.5 Surface Water and Sediments

Surface water provides a pathway for transporting potential contaminants from the Solar Ponds area. North Walnut Creek may receive contaminates from the pond leakage via lateral ground water flow, leaching from the vadose zone, and contaminated surficial soil transport by way of stormwater runoff. A series of dams, retention ponds, diversion structures, and ditches has been constructed at the Plant to control surface water, and to limit the potential for release of poor quality water. Some of the ponds are located in the drainages of North Walnut Creek. The creek and associated surface water control structures eventually lead to a reservoir, where the potential contaminants could be concentrated in sediments. The ability of contaminants to be bound to sediments or transported in the dissolved phase is dependent on both contaminant characteristics and environmental conditions.

The surface water system represents a potential route of exposure from ingestion/absorption/inhalation and direct contact exposure routes. If present, dissolved and suspended transition metals, radionuclides, organics, and other contaminants may be released to, and transported by, the surface water system. Any volatiles present in surface water may be released to the atmosphere. Sediment from North Walnut Creek may currently act as an accumulation point for contaminants. These sediments may also be resuspended and diverted downstream during high flows.

2.6.6 Air

Air transmission of potential soil contaminants from the Solar Ponds may occur during the windy, dry periods of the year. Airborne release may also occur, to a limited extent, during site investigative activities or remedial actions if effective protective measures are not taken. Aerosols may be entrained in air from pond liquids during windy periods. Volatile organic compounds may also be released from pond liquids and sludges, as well as environmental media exposed to the atmosphere. Migration pathways correspond to local wind-flow patterns. Inhalation exposure is contingent on the proximity of receptor to the Solar Ponds area, although small particles, less than 10 microns in size, may be carried great distances. However, these particles will be well-dispersed and generally

in low concentration. Surficial soils will be sampled to evaluate for possible contamination that could be transport as wind-blown dust.

2.6.7 Biota

Approximately two-thirds of the Solar Ponds area is located on open ground, without irrigation. The remaining one-third of the area is highly developed and includes the ponds, buildings, and pavements.

2.6.8 Receptors and Pathways

The ultimate estimate of the fate and transport of contaminants in the OU4 area depends on the acquisition of the data to properly interpret the sources(s), release(s), transport mechanism(s) and exposure pathways. Receptors are the populations exposed to contaminants at potential points of contact with a contaminated medium. Under current and future land use scenarios at OU4, human receptors include primarily plant workers, and secondarily, residents living near RFP. The primary pathways by which human receptors may potentially be exposed to contaminants include exposure to volatiles, windblown aerosols and dust, direct contact with the surface water and sediments, ingestion and absorption of surface water and ground water, direct ingestion of surficial soils, ingestion of vegetation grown in soil, and consumption of wildlife.

Environmental receptors include vegetation, cold water game fish, migratory waterfowl and terrestrial mammals. These potential receptors could be exposed through the same routes as human receptors, with the exception of ground water.

TABLE 2.1
COMPARISON OF HYDRAULIC PROPERTIES

Source	Formation	Hydraulic Conductivity cm/s
Ground Water Assessment Plan Addendum - Draft, EG&G, 1990.	Valley Fill	9×10^{-5}
	Alluvium	$5.3 \times 10^{-4} - 2.1 \times 10^{-5}$
	Bedrock	$5.4 \times 10^{-7} - 4 \times 10^{-8}$
Hydrogeological Characterization of the Rocky Flats Plant, Hydro-Search, 1985.	Alluvium	1×10^{-3}
	Arapahoe Sandstone	4×10^{-5}
	Arapahoe Claystone	3×10^{-7}
Section E Groundwater Protection, Rockwell International, 1986.	Rocky Flats Alluvium	7×10^{-5}
	Walnut Creek Alluvium	3×10^{-5}
	Woman Creek Alluvium	3×10^{-3}
	Arapahoe Sandstone	2×10^{-6}
	Weathered Arapahoe Claystone	5×10^{-7}
	Unweathered Arapahoe Claystone	1×10^{-7}
	Qal (Valley Fill)	2×10^{-4}
Draft Final Groundwater Protection and Monitoring Plan, EG&G, 1991.	Rocky Flats Alluvium Arapahoe Sandstone #1	6×10^{-5}
	Arapahoe Sandstone #3, 4, 5	10^{-6}
	Basal Arapahoe Sandstone	10^{-6}
	Arapahoe Claystone (Weathered and Unweathered)	$10^{-7} - 10^{-8}$
RCRA Part B Permit Application, Rockwell International, 1988.	Rocky Flats Alluvium	7×10^{-5}
	Valley Fill	3×10^{-3}
	Arapahoe Formation	$2 \times 10^{-6} - 1 \times 10^{-7}$
Hydrology of a Nuclear-Processing Plant Site, Hurr, 1976.	Rocky Flats Alluvium	1×10^{-2}
	Valley Fill	NA
	Arapahoe Formation	1×10^{-4}
RCRA Post Closure Care Permit Application, Rockwell International, 1988.	Rocky Flats Alluvium	$9 \times 10^{-6} - 4 \times 10^{-8}$
	Valley Fill	5×10^{-6}
	Arapahoe Formation	NA

SOURCE: 1990 Annual RCRA Groundwater Monitoring Report (EG&G, 1991d).

TABLE 2.2

FIRST QUARTER 1990 WATER LEVELS IN SURFICIAL MATERIALS

COLLUVIAL WELLS	1/90 (ft)	2/90 (ft)	3/90 (ft)
B208789	5897.58	5897.41	N/A
B208389	DRY	N/A	N/A
B210489	5853.71	5853.79	N/A
1886	DRY	N/A	N/A
P209989	DRY	N/A	N/A
B208089	5923.20	N/A	N/A
2086	DRY	DRY	N/A
3386	DRY	DRY	N/A
2187	5919.01	5919.67	DRY
ALLUVIAL WELLS	1/90 (ft)	2/90 (ft)	3/90 (ft)
P209289	DRY	N/A	N/A
2886	5955.27	5955.02	N/A
2286	5967.79	5967.51	N/A
5687	5970.68	5970.79	N/A
P207889	5957.73	5957.68	N/A
2986	DRY	N/A	N/A
P209789	5956.12	N/A	5961.60
3787	5960.04	N/A	5962.81
P207689	5959.39	N/A	N/A
2686	5964.92	DRY	N/A
2486	DRY	N/A	N/A
P207489	N/A	N/A	N/A
3887	5963.15	5963.00	N/A
0460	5965.13	N/A	5972.02
VALLEY FILL WELLS	1/90 (ft)	2/90 (ft)	3/90 (ft)
B208589	5853.45	N/A	5854.52
1586	5841.06	5841.12	N/A
1386	5834.44	5834.50	N/A
3686	5878.07	N/A	N/A
3586	5902.19	N/A	N/A
1786	5958.94	5860.32	N/A

NOTES: 1. See Figure 2-15 for well locations in the Solar Evaporation Ponds Area.
 2. Datum is mean sea level.
 3. N/A is defined as Not Available.

SOURCE: 1990 Annual RCRA Groundwater Monitoring Report (EG&G, 1991d).

TABLE 2.3

THIRD QUARTER 1990 WATER LEVELS IN SURFICIAL MATERIALS

COLLUVIAL WELLS	7/90 (ft)	8/90 (ft)	9/90 (ft)
B208789	5895.31	5895.07	5895.35
B208389	DRY	DRY	N/A
B210489	5852.91	N/A	N/A
1886	DRY	DRY	DRY
P209989	DRY	DRY	DRY
B208089	5924.09	5924.11	5923.84
2086	5950.21	DRY	DRY
3386	5942.41	DRY	N/A
2187	5920.67	DRY	5922.94
ALLUVIAL WELLS	7/90 (ft)	8/90 (ft)	9/90 (ft)
P209289	DRY	5968.77	5969.04
2886	5956.99	5956.93	5956.16
2286	N/A	5969.19	N/A
5687	5972.40	5970.57	5971.78
P207889	5959.16	N/A	N/A
2986	DRY	DRY	DRY
P209789	5957.83	N/A	N/A
3787	5962.15	5961.62	5961.30
P207689	5960.20	N/A	N/A
2686	5965.31	5965.23	5964.96
2486	DRY	DRY	DRY
P207489	5975.35	5975.04	5974.65
3887	5964.28	5964.02	N/A
0406	N/A	5966.15	N/A
VALLEY FILL WELLS	7/90 (ft)	8/90 (ft)	9/90 (ft)
B208589	5882.52	N/A	N/A
1586	5840.90	N/A	N/A
1386	5832.27	5832.62	5930.02
3686	5876.36	5876.12	N/A
3586	5903.04	5902.34	N/A
1786	5860.10	5860.07	5860.04

NOTES: 1. See Figure 2-15 for well locations in the Solar Evaporation Ponds Area.
 2. Datum is mean sea level.
 3. N/A is defined as Not Available.

SOURCE: 1990 Annual RCRA Groundwater Monitoring Report (EG&G, 1991d).

TABLE 2.4
SOLAR EVAPORATION PONDS
CONSTRUCTION DETAILS FOR THE MONITORING WELLS

Well No.	Completion Zone ⁴	Screened Interval (ft.) ³	Borehole Total Depth (ft.) ³	Surface Elevation ³
0260	Kacl(w) ¹	NA	NA	5934.60
0460	Qrf ¹	NA	NA	5962.00
1386	Qvf ¹	3.09-9.50	15.50	5837.22
1486	Kass(u) ¹	39.42-55.36	74.00	5844.71
1586	Qvf ¹	4.09-14.69	18.00	5845.61
1686	Kass(u) ¹	39.06-45.06	64.00	5864.74
1786	Qvf ¹	3.73-13.98	19.20	5865.26
1886	Qc ¹	3.74-7.50	10.50	5882.82
1986	Qc ²	3.00-12.25	16.50	5946.00
2086	Qc ¹	4.21-10.55	22.00	5960.47
2186	Qc ¹	35.00-67.24 ⁴	78.00	5991.11 ⁴
2286	Qrf ¹	3.20-11.20	26.00	5976.81
2386	Kass(u) ¹	113.00-117.25	130.50	5981.18
2486	Qrf ¹	2.95-7.45	12.00	5980.45
2586	Kass(u) ¹	59.90-82.00	89.80	5974.45
2686	Qrf ¹	3.75-11.00	17.00	5974.48
2786	Kass(u) ¹	128.50-133.00	157.00	5961.86
2886	Qrf ¹	4.03-8.60	15.50	5961.23
2986	Qrf ¹	2.83-8.77	22.50	5958.26
3086	Kacl(w) ¹	2.48-14.93	16.00	5956.21
3186	Kass(w) ¹	2.46-17.32	22.00	5964.21
3286	Kass(u) ¹	114.90-125.50	135.00	5964.46
3386	Qc ²	2.99-7.34	16.80	5949.28
0387	Qd/Qrf	102.80-108.00	117.00	5930.58
0487	Qd/Qrf	3.50-6.70	13.00	5882.69
SP0687	Qaf/Qrf ²	NA	30.70	5972.90
SP0787	Qaf/Qrf ²	NA	31.00	5973.60
SP0887	Qd/Qc ²	109.99-117.39	140.00	5947.10
SP0987	Qd/Qc ²	NA	11.00	5945.00
SP1087	Qd/Qc ²	NA	22.70	5941.00
SP1187	Qd/Qc ²	NA	34.00	5904.50

TABLE 2.4 (Continued)

**SOLAR EVAPORATION PONDS
CONSTRUCTION DETAILS FOR THE MONITORING WELLS**

Well No.	Completion Zone ⁴	Screened Interval (ft.) ³	Borehole Total Depth (ft.) ³	Surface Elevation ³
3787	Qd/Qrf ²	3.50-12.50	13.00	5967.03
3887	Qd/Qrf ²	3.50-9.50	14.00	5971.79
3987 (SP0887)	NA	109.99-117.39	140.00	5947.10
5087 (SP1687)	Qd/Qrf ²	3.52-9.92	13.40	5978.51
P207389	Kass(w)	10.53-15.18	23.30	5981.02
P207489	Qrf	2.39-7.00	10.00	5980.71
P207589	Kacl	14.40-23.86	29.10	5974.06
P207689	Qrf	3.64-13.10	18.20	5966.32
P207789	Kacl	17.90-27.34	32.30	5965.88
P207889	Qrf	3.26-7.70	10.50	5962.82
P207989	Kacl	11.00-20.48	26.20	5963.09
B208089	Qc	3.40-12.90	22.20	5935.40
B208189	Kacl	16.90-26.34	32.50	5935.40
B208289	Kacl	5.95-15.42	19.00	5850.70
B208389	Qc	3.37-7.30	16.30	5876.80
B208489	Kacl	19.76-29.22	33.20	5876.30
B208589	Qvf	3.23-3.99	9.60	5856.50
B208689	Kacl	12.32-21.80	28.40	5867.60
B208789	Qvf	2.88-10.93	14.40	5907.10
P208889	Kass(u)	87.76-96.94	105.70	5947.30
P208989	Kacl	15.40-25.80	28.60	5962.53
P209089	Kacl	16.50-25.96	31.50	5972.16
P209189	Kass(w)	13.30-35.01	38.30	5980.66
P209289	Qrf	8.20-12.66	17.80	5981.59
P209389	Kass(w)	16.82-28.80	34.20	5981.47
P209489	Kass(w)	15.48-35.00	48.00	5977.98
P209589	Kacl	9.07-18.52	30.30	5948.17
P209689	Kacl	17.20-26.67	30.20	5962.63
P209789	Qrf	3.00-12.50	17.50	5962.82
P209889	Kacl	8.89-18.83	23.90	5940.28
P209989	Qc	3.81-8.18	12.00	5898.10

TABLE 2.4 (Continued)

**SOLAR EVAPORATION PONDS
CONSTRUCTION DETAILS FOR THE MONITORING WELLS**

Well No.	Completion Zone ⁴	Screened Interval (ft.) ³	Borehole Total Depth (ft.) ³	Surface Elevation ³
P210089	Kacl	12.20-21.50	28.00	5898.40
P210189	Kass(w)	20.40-36.50	38.60	5980.82
P210289	Kacl	11.57-21.00	26.00	5967.03
B210389	Kacl	13.61-23.07	28.50	5873.20
B310489	Qc	2.98-7.41	28.10	5856.40
P213789	Qrf ²	2.46-6.90	9.60	5917.80
P213889	Qrf ²	11.30-20.83	31.85	5954.10
P213989	Qrf ²	3.29-6.92	9.70	5954.30
P219089	Qrf ²	5.00-14.44	20.00	5949.10
P219189	Qrf ²	7.08-11.90	21.00	5941.20
P219489	Qrf ²	18.48-22.90	32.00	5959.50

¹ 1990 Annual RCRA Groundwater Monitoring Report, 1991, Volume I

² EG&G Geologic Characterization, 1991

³ Well Completion and Geologic Logs from Rockwell International, Closure Plan, 1988, Volume III or Summary of Field Activities, EG&G 1990

⁴ Completion Zone Information from Summary of Field Activities, EG&G 1990, except where noted.

KEY:

Qaf	Artificial Fill
Qd	Disturbed Ground
Qrf	Rocky Flats Alluvium
Qc	Colluvium
Qvf	Valley Fill Alluvium
Kacl & Kacl(w)	Weathered Arapahoe Formation Claystone
Kass(w)	Weathered Arapahoe Formation Sandstone
Kass(u)	Unweathered Arapahoe Formation Sandstone
NA	Not Available

TABLE 2.5

FIRST QUARTER 1990 WATER LEVELS IN WEATHERED BEDROCK

SITE	1/90 (ft)	2/90 (ft)	3/90 (ft)
0260	5922.31	N/A	5929.02
3086	5952.02	5952.09	N/A
3186	DRY	N/A	N/A
B208189	5915.84	5917.28	N/A
B208289	5835.87	5934.93	N/A
B208689	5859.60	N/A	5860.23
B210389	5851.81	5852.41	N/A
B207389	5974.94	N/A	5976.83
P207789	5939.11	5939.22	N/A
P207989	5948.09	5948.71	N/A
P209389	5963.83	N/A	5967.14
P209489	DRY	N/A	N/A
P209589	5932.05	N/A	N/A
P209689	5936.24	N/A	5936.83
P209889	5937.25	N/A	5937.88
P210089	5881.71	5881.57	N/A
P210189	5967.65	N/A	N/A
P210289	5950.92	N/A	5953.44
P213889	DRY	N/A	N/A

- Notes:
1. See Figure 2-15 for well locations in the Solar Evaporation Ponds Area.
 2. Datum is mean sea level.
 3. N/A is defined as Not Available.

SOURCE: 1990 Annual RCRA Groundwater Monitoring Report (EG&G, 1991d).

TABLE 2.6

THIRD QUARTER 1990 WATER LEVELS IN WEATHERED BEDROCK

SITE	7/90 (ft)	8/90 (ft)	9/90 (ft)
0260	N/A	5929.40	N/A
3086	5951.97	5952.20	N/A
3186	DRY	N/A	N/A
B208189	N/A	5912.45	5914.08
B208289	5835.84	N/A	N/A
B208689	5853.35	N/A	N/A
B210389	N/A	N/A	5852.20
B207389	5975.80	5975.23	N/A
P207789	5938.22	5938.71	N/A
P207989	5946.98	5949.48	N/A
P209389	5964.89	5965.85	N/A
P209489	5951.42	5951.52	N/A
P209589	5931.02	5929.26	N/A
P209689	5935.80	N/A	N/A
P209889	5937.34	5937.40	N/A
P210089	5879.69	5881.66	N/A
P210189	5969.12	5970.05	N/A
P210289	5951.51	N/A	N/A
P213889	DRY	DRY	DRY

- Notes:
1. See Figure 2-15 for well locations in the Solar Evaporation Ponds Area.
 2. Datum is mean sea level.
 3. N/A is defined as Not Available.

SOURCE: 1990 Annual RCRA Groundwater Monitoring Report (EG&G, 1991d).

TABLE 2.7

**SOLAR EVAPORATION POND 207A
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207A Liquid		207A Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
ANIONS					
Ammonia	ppm	NA	0.43	NA	NA
Bicarbonate	ppm	NA	35	NA	NA
Carbonate	ppm	NA	47	NA	NA
Chloride	ppm	NA	416	NA	NA
Cyanide, Total	ppm	ND - 1.7	0.478	NA	NA
Fluoride	ppm	NA	ND	NA	NA
Nitrate, N	ppm	ND - 21,739	1000	8800	NA
Nitrite	ppm	NA	39	NA	NA
Phosphate, Ortho	ppm	NA	ND	NA	NA
Phosphate, Total	ppm	NA	ND	NA	NA
Sulfate	ppm	NA	409	NA	NA
Sulfide	ppm	NA	ND	NA	NA
TKN-N	ppm	NA	ND	NA	NA
RADIONUCLIDES					
Americium -241	pCi/l	ND - 200	0.42	NA	NA
Americium -241	pCi/g	NA	NA	1400-4400	NA
Plutonium -239	pCi/l	ND - 660	0.71	ND	NA
Plutonium -239	pCi/g	NA	NA	1000-3700	NA
Uranium -234	pCi/l	14000-20000	310	NA	NA
Uranium -234	pCi/g	NA	NA	70-570	NA
Uranium -235	pCi/l	NA	11	28-28	NA
Uranium -235	pCi/g	NA	NA	28-28	NA
Uranium -238	pCi/l	21000-28000	340	520-520	NA
Uranium -238	pCi/g	NA	NA	130-480	NA
Uranium	pCi/l	0.7-26000	ND	NA	NA
Tritium	pCi/l	240-3000	NA	NA	NA
Tritium	pCi/g	NA	NA	1300-12000	NA
Gross Alpha	pCi/l	32-80000	300	NA	NA
Gross Beta	pCi/l	2-40000	930	NA	NA

TABLE 2.7 (continued)

**SOLAR EVAPORATION POND 207A
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207A Liquid		207A Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
MISCELLANEOUS TESTS					
Alkalinity, Total	ppm	NA	110	NA	NA
Conductivity @ 25C	uMHOs	NA	8800	NA	NA
Total Dissolved Solids	ppm	127000-127000	7600	NA	NA
Total Organic Carbon	ppm	NA	67.8	NA	NA
Total Suspended Solids	%	NA	23	NA	NA
pH	ppm	8.3-11	9.9	9.5	NA
METALS					
Aluminum	ppm	2.31-2.64	ND	11000-11900	NA
Antimony	ppm	NA	ND	NA	NA
Arsenic	ppm	0.015-0.015	ND	ND	NA
Barium	ppm	ND	NA	ND	NA
Beryllium	ppm	ND-0.1	NA	309-1570	NA
Bismuth	ppm	NA	ND	NA	NA
Boron	ppm	NA	1.26	NA	NA
Cadmium	ppm	0.070-0.150	ND	1110-10500	NA
Calcium	ppm	ND	60.4	19600-50000	NA
Cerium	ppm	NA	NA	NA	NA
Cesium	ppm	NA	NA	NA	NA
Cobalt	ppm	0.200-0.500	NA	ND	NA
Chromium, Total	ppm	13.7-16.7	ND	1010-19700	NA
Chromium, Hexavalent	ppm	NA	NA	ND-1.0	NA
Copper	ppm	1.61-1.8	ND	425-1590	NA
Germanium	ppm	NA	NA	NA	NA
Iron	ppm	1.5-8.0	ND	3590-6900	
Lead	ppm	ND	0.004	65-455	NA
Lithium	ppm	NA	1.42	NA	NA
Magnesium	ppm	ND	121	6100-21000	NA
Manganese	ppm	0.095-0.115	ND	153-595	NA
Mercury	ppm	ND-0.0002	ND	7.5-25	NA

TABLE 2.7 (continued)

SOLAR EVAPORATION POND 207A
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS

Compound	Units	207A Liquid		207A Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
Molybdenum	ppm	NA	ND	NA	NA
Nickel	ppm	1.9-2.0	ND	124-1320	NA
Niobium	ppm	NA	NA	NA	NA
Phosphorous	ppm	NA	NA	NA	NA
Potassium	ppm	13200-14300	376	50000-65300	NA
Rubidium	ppm	NA	NA	NA	NA
Selenium	ppm	ND	0.015	ND	NA
Silicon	ppm	NA	0.846	NA	NA
Silver	ppm	NA	ND	153-237	NA
Sodium	ppm	36300-42900	1610	130000-166000	NA
Strontium	ppm	NA	2.35	NA	NA
Tantalum	ppm	NA	NA	NA	NA
Tellurium	ppm	NA	NA	NA	NA
Thallium	ppm	NA	ND	NA	NA
Thorium	ppm	NA	NA	NA	NA
Tin	ppm	7-13	ND	ND	NA
Titanium	ppm	NA	NA	NA	NA
Tungsten	ppm	NA	NA	NA	NA
Vanadium	ppm	0.10-0.20	NA	NA	NA
Zirconium	ppm	NA	NA	NA	NA
Zinc	ppm	0.62-0.78	0.028	227-595	NA
VOLATILE ORGANICS					
Acetone	ppb	100-260	3.0	5-4680	NA
Methylene Chloride	ppb	ND	5.0	ND	NA
Tetrachloroethene	ppb	ND	ND	ND-1200	NA
SEMIVOLATILE					
Acenaphthene	ppb	NA	ND	NA	NA
Bis(2-ethylhexyl) phthalate	ppb	NA	ND	ND-14900	NA
4-Chloro-3-methylphenol	ppb	NA	ND	NA	NA
2-Chlorophenol	ppb	NA	ND	NA	NA

TABLE 2.7 (continued)

**SOLAR EVAPORATION POND 207A
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207A Liquid		207A Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
1,4-Dichlorobenzene	ppb	NA	ND	NA	NA
2,4-Dinitrotoluene	ppb	NA	ND	NA	NA
Di-n-butyl phthalate	ppb	NA	ND	ND-590	NA
Fluoranthene	ppb	NA	ND	161-1680	NA
N-Nitroso-di-propylamine	ppb	NA	ND	NA	NA
Phenol	ppb	NA	ND	NA	NA
Phenols, Total	ppb	13-35	NA	ND-3300	NA
Pyrene	ppb	NA	ND	NA	NA
1,2,4-Trichlorobenzene	ppb	NA	ND	NA	NA
PESTICIDES/PCBs					
Atrazine	ppb	NA	3.5	NA	NA
Diazinon	ppb	NA	ND	NA	NA
Simazine	ppb	NA	ND	NA	NA

References: Rockwell International, 1988a, Solar Evaporation Ponds Closure Plan
Dames and Moore, 1991, A Summary of Chemical Analyses of Sludge and Water

NA -- Not Analyzed

ND -- Not Detected

TABLE 2.8

**SOLAR EVAPORATION POND 207B (NORTH)
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207B (North) Liquid		207B (North) Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
ANIONS					
Ammonia	ppm	NA	ND	NA	102
Bicarbonate	ppm	NA	ND	NA	ND
Carbonate	ppm	NA	ND	NA	ND
Chloride	ppm	NA	147	NA	1910
Cyanide, Total	ppm	NA	37.8	NA	ND
Fluoride	ppm	NA	ND	NA	ND
Nitrate, N	ppm	212 - 1367	39	NA	600
Nitrite	ppm	NA	ND	NA	10
Phosphate, Ortho	ppm	NA	ND	NA	4
Phosphate, Total	ppm	NA	0.04	NA	ND
Sulfate	ppm	NA	155	NA	ND
Sulfide	ppm	NA	ND	NA	56
TKN-N	ppm	NA	ND	NA	1430
RADIONUCLIDES					
Americium -241	pCi/l	ND	0.14	NA	ND
Americium -241	pCi/g	NA	NA	NA	NA
Plutonium -239	pCi/l	ND	ND	NA	2.2
Plutonium -239	pCi/g	NA	NA	NA	NA
Uranium -234	pCi/l	50 - 53	40	NA	13
Uranium -234	pCi/g	NA	NA	NA	NA
Uranium -235	pCi/l	NA	1.7	NA	0.4
Uranium -235	pCi/g	NA	NA	NA	NA
Uranium -238	pCi/l	31 - 33	26	NA	8.4
Uranium -238	pCi/g	NA	NA	NA	NA
Uranium	pCi/l	NA	ND	NA	ND
Tritium	pCi/l	1200 - 1300	NA	NA	NA
Tritium	pCi/g	NA	NA	NA	NA
Gross Alpha	pCi/l	13 - 323	59	NA	33
Gross Beta	pCi/l	5 - 200	110	NA	46

TABLE 2.8 (continued)

**SOLAR EVAPORATION POND 207B (NORTH)
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207B (North) Liquid		207B (North) Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
MISCELLANEOUS TESTS					
Alkalinity, Total	ppm	NA	75	NA	290
Conductivity @ 25C	uMHOs	NA	3380	NA	589
Total Dissolved Solids	ppm	NA	3200	NA	NA
Total Organic Carbon	ppm	NA	7.6	NA	11000
Total Suspended Solids	%	NA	18	NA	26
pH	ppm	7.5 - 9.6	8.5	NA	7.3
METALS					
Aluminum	ppm	ND - 1.00	ND	NA	4140
Antimony	ppm	ND	ND	NA	ND
Arsenic	ppm	ND	ND	NA	ND
Barium	ppm	ND - 0.22	ND	NA	NA
Beryllium	ppm	ND - 0.06	NA	NA	NA
Bismuth	ppm	ND	ND	NA	ND
Boron	ppm	0.09 - 0.31	0.173	NA	ND
Cadmium	ppm	ND - 0.01	ND	NA	12
Calcium	ppm	20 - 290	189	NA	247000
Cerium	ppm	ND	NA	NA	NA
Cesium	ppm	ND	NA	NA	NA
Cobalt	ppm	ND	NA	NA	NA
Chromium, Total	ppm	ND	ND	NA	33
Chromium, Hexavalent	ppm	NA	NA	NA	NA
Copper	ppm	ND	ND	NA	ND
Germanium	ppm	ND	NA	NA	NA
Iron	ppm	ND - 0.29	ND	NA	4530
Lead	ppm	ND - 0.004	ND	NA	12
Lithium	ppm	0.37 - 6	0.332	NA	ND
Magnesium	ppm	66 - 120	79.3	NA	4670
Manganese	ppm	ND - 0.015	ND	NA	80
Mercury	ppm	ND	ND	NA	ND

TABLE 2.8 (continued)

**SOLAR EVAPORATION POND 207B (NORTH)
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207B (North) Liquid		207B (North) Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
Molybdenum	ppm	ND - 0.0069	ND	NA	ND
Nickel	ppm	ND - 0.05	ND	NA	ND
Niobium	ppm	ND	NA	NA	NA
Phosphorous	ppm	ND	NA	NA	NA
Potassium	ppm	56 - 120	58.8	NA	ND
Rubidium	ppm	ND	NA	NA	NA
Selenium	ppm	ND - 0.024	0.008	NA	ND
Silicon	ppm	ND - 5.6	1.02	NA	2670
Silver	ppm	ND - 0.082	ND	NA	ND
Sodium	ppm	363 - 820	403	NA	ND
Strontium	ppm	0.14 - 3.5	2.22	NA	692
Tantalum	ppm	ND	NA	NA	NA
Tellurium	ppm	ND	NA	NA	NA
Thallium	ppm	ND	ND	NA	7
Thorium	ppm	ND	NA	NA	NA
Tin	ppm	ND	ND	NA	ND
Titanium	ppm	ND	NA	NA	NA
Tungsten	ppm	ND	NA	NA	NA
Vanadium	ppm	ND	NA	NA	NA
Zirconium	ppm	ND	NA	NA	NA
Zinc	ppm	ND - 0.022	0.048	NA	101
VOLATILE ORGANICS					
Acetone	ppb	ND	ND	NA	ND
Methylene Chloride	ppb	19-71	ND	NA	ND
Tetrachloroethene	ppb	ND	ND	NA	ND
SEMIVOLATILE					
Acenaphthene	ppb	NA	ND	NA	4500
Bis(2-ethyl hexyl) phthalate	ppb	NA	ND	NA	NA
4-Chloro-3-methylphenol	ppb	NA	ND	NA	7900
2-Chlorophenol	ppb	NA	ND	NA	7700

TABLE 2.8 (continued)

**SOLAR EVAPORATION POND 207B (NORTH)
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207B (North) Liquid		207B (North) Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
1,4-Dichlorobenzene	ppb	NA	ND	NA	4000
2,4-Dinitrotoluene	ppb	NA	ND	NA	3500
Di-nbutyl phthalate	ppb	NA	ND	NA	ND
Fluoranthene	ppb	NA	ND	NA	ND
N-Nitroso-di-propylamine	ppb	NA	ND	NA	3900
Phenol	ppb	NA	ND	NA	7400
Phenols, Total	ppb	3 - 46	NA	NA	NA
Pyrene	ppb	NA	ND	NA	4600
1,2,4-Trichlorobenzene	ppb	NA	ND	NA	4300
PESTICIDES/PCBs					
Atrazine	ppb	NA	1.1	NA	ND
Diazinon	ppb	NA	ND	NA	ND
Simazine	ppb	NA	ND	NA	ND

References: Rockwell International, 1988a, Solar Evaporation Ponds Closure Plan
Dames and Moore, 1991, A Summary of Chemical Analyses of Sludge and Water

NA -- Not Analyzed

ND -- Not Detected

TABLE 2.9

**SOLAR EVAPORATION POND 207B (CENTER)
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207B (Center) Liquid		207B (Center) Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
ANIONS					
Ammonia	ppm	NA	0.5	NA	135
Bicarbonate	ppm	NA	ND	NA	ND
Carbonate	ppm	NA	280	NA	ND
Chloride	ppm	NA	763	NA	11200
Cyanide, Total	ppm	NA	0.555	NA	ND
Fluoride	ppm	NA	73	NA	ND
Nitrate, N	ppm	ND - 1220	1600	NA	13000
Nitrite	ppm	NA	75	NA	470
Phosphate, Ortho	ppm	NA	ND	NA	14
Phosphate, Total	ppm	NA	3.1	NA	2100
Sulfate	ppm	NA	736	NA	6950
Sulfide	ppm	NA	ND	NA	ND
TKN-N	ppm	NA	ND	NA	16700
RADIONUCLIDES					
Americium -241	pCi/l	NA	5.5	NA	ND
Americium -241	pCi/g	NA	NA	NA	NA
Plutonium -239	pCi/l	NA	0.4	NA	5.1
Plutonium -239	pCi/g	NA	NA	NA	NA
Uranium -234	pCi/l	NA	780	NA	70
Uranium -234	pCi/g	NA	NA	NA	NA
Uranium -235	pCi/l	NA	36	NA	2.5
Uranium -235	pCi/g	NA	NA	NA	NA
Uranium -238	pCi/l	NA	900	NA	75
Uranium -238	pCi/g	NA	NA	NA	NA
Uranium	pCi/l	NA	ND	NA	ND
Tritium	pCi/l	NA	NA	NA	NA
Tritium	pCi/g	NA	NA	NA	NA
Gross Alpha	pCi/l	4 - 2500	2400	NA	120
Gross Beta	pCi/l	8 - 1500	3900	NA	380

TABLE 2.9 (continued)

**SOLAR EVAPORATION POND 207B (CENTER)
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207B (Center) Liquid		207B (Center) Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
MISCELLANEOUS TESTS					
Alkalinity, Total	ppm	NA	1000	NA	2700
Conductivity @ 25C	uMHOs	NA	1350	NA	3700
Total Dissolved Solids	ppm	NA	13000	NA	ND
Total Organic Carbon	ppm	NA	126	NA	22000
Total Suspended Solids	%	NA	15	NA	10
pH	ppm	7.3-11.3	9.1	NA	9.2
METALS					
Aluminum	ppm	ND - 2.00	ND	NA	2350
Antimony	ppm	ND	ND	NA	ND
Arsenic	ppm	ND	0.014	NA	ND
Barium	ppm	ND	ND	NA	ND
Beryllium	ppm	ND	ND	NA	ND
Bismuth	ppm	ND	ND	NA	ND
Boron	ppm	0.071 - 0.67	2.77	NA	ND
Cadmium	ppm	ND-0.01	ND	NA	108
Calcium	ppm	2.9- 95	22.6	NA	108000
Cerium	ppm	ND	NA	NA	NA
Cesium	ppm	ND - 0.35	NA	NA	NA
Cobalt	ppm	ND	NA	NA	NA
Chromium, Total	ppm	ND	0.094	NA	127
Chromium, Hexavalent	ppm	NA	NA	NA	97
Copper	ppm	ND - 0.037	0.035	NA	96
Germanium	ppm	ND	NA	NA	NA
Iron	ppm	ND - 0.2	ND	NA	2650
Lead	ppm	ND - 0.002	ND	NA	13
Lithium	ppm	0.052 - 3.5	2.6	NA	ND
Magnesium	ppm	3.9 - 91	181	NA	13700
Manganese	ppm	ND - 0.022	ND	NA	208
Mercury	ppm	ND	ND	NA	2

TABLE 2.9 (continued)

**SOLAR EVAPORATION POND 207B (CENTER)
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207B (Center) Liquid		207B (Center) Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
Molybdenum	ppm	0.004 - 0.037	ND	NA	ND
Nickel	ppm	ND - 0.016	ND	NA	ND
Niobium	ppm	ND	NA	NA	NA
Phosphorous	ppm	ND - 0.2	NA	NA	NA
Potassium	ppm	30 - 110	729	NA	ND
Rubidium	ppm	ND	NA	NA	NA
Selenium	ppm	ND - 0.019	ND	NA	ND
Silicon	ppm	1.4 - 5.5	1.41	NA	2690
Silver	ppm	ND - 0.015	ND	NA	ND
Sodium	ppm	67 - 800	2440	NA	31300
Strontium	ppm	0.14 - 0.52	2.13	NA	848
Tantalum	ppm	ND	NA	NA	NA
Tellurium	ppm	ND	NA	NA	NA
Thallium	ppm	ND	ND	NA	ND
Thorium	ppm	ND	NA	NA	ND
Tin	ppm	ND	0.109	NA	ND
Titanium	ppm	ND	NA	NA	NA
Tungsten	ppm	ND	NA	NA	NA
Vanadium	ppm	ND - 0.0081	NA	NA	NA
Zirconium	ppm	ND - 0.004	NA	NA	NA
Zinc	ppm	ND - 0.041	ND	NA	186
VOLATILE ORGANICS					
Acetone	ppb	NA	ND	NA	ND
Methylene Chloride	ppb	NA	ND	NA	ND
Tetrachloroethene	ppb	NA	ND	NA	ND
SEMIVOLATILE					
Acenaphthene	ppb	NA	ND	NA	ND
Bis(2-ethyl hexyl) phthalate	ppb	NA	ND	NA	ND
4-Chloro-3-methylphenol	ppb	NA	ND	NA	ND
2-Chlorophenol	ppb	NA	ND	NA	ND

TABLE 2.9 (continued)

**SOLAR EVAPORATION POND 207B (CENTER)
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207B (Center) Liquid		207B (Center) Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
1,4-Dichlorobenzene	ppb	NA	ND	NA	ND
2,4-Dinitrotoluene	ppb	NA	ND	NA	ND
Di-n-butyl phthalate	ppb	NA	ND	NA	ND
Fluoranthene	ppb	NA	ND	NA	ND
N-Nitroso-di-propylamine	ppb	NA	ND	NA	ND
Phenol	ppb	NA	ND	NA	ND
Phenols, Total	ppb	NA	NA	NA	NA
Pyrene	ppb	NA	ND	NA	ND
1,2,4-Trichlorobenzene	ppb	NA	ND	NA	ND
PESTICIDES/PCBs					
Atrazine	ppb	NA	9	NA	ND
Diazinon	ppb	NA	ND	NA	ND
Simazine	ppb	NA	ND	NA	ND

References: Rockwell International, 1988a, Solar Evaporation Ponds Closure Plan
Dames and Moore, 1991, A Summary of Chemical Analyses of Sludge and Water

NA -- Not Analyzed

ND -- Not Detected

TABLE 2.10

**SOLAR EVAPORATION POND 207B (SOUTH)
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207B (South) Liquid		207B (South) Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
ANIONS					
Ammonia	ppm	NA	0.97	NA	256
Bicarbonate	ppm	NA	ND	NA	ND
Carbonate	ppm	NA	190	NA	ND
Chloride	ppm	NA	745	NA	11300
Cyanide, Total	ppm	NA	0.509	NA	ND
Fluoride	ppm	NA	72.5	NA	ND
Nitrate, N	ppm	NA	1800	NA	11000
Nitrite	ppm	NA	100	NA	860
Phosphate, Ortho	ppm	NA	ND	NA	23
Phosphate, Total	ppm	NA	2.6	NA	260
Sulfate	ppm	NA	784	NA	8530
Sulfide	ppm	NA	1.0	NA	ND
TKN-N	ppm	NA	ND	NA	12100
RADIONUCLIDES					
Americium -241	pCi/l	NA	0.1	NA	2.4
Americium -241	pCi/g	NA	NA	NA	NA
Plutonium -239	pCi/l	NA	0.1	NA	1.9
Plutonium -239	pCi/g	NA	NA	NA	NA
Uranium -234	pCi/l	NA	760	NA	130
Uranium -234	pCi/g	NA	NA	NA	NA
Uranium -235	pCi/l	NA	31	NA	2.9
Uranium -235	pCi/g	NA	NA	NA	NA
Uranium -238	pCi/l	NA	870	NA	150
Uranium -238	pCi/g	NA	NA	NA	NA
Uranium	pCi/l	NA	ND	NA	ND
Tritium	pCi/l	NA	NA	NA	NA
Tritium	pCi/g	NA	NA	NA	NA
Gross Alpha	pCi/l	NA	1600	NA	150
Gross Beta	pCi/l	NA	2300	NA	530

TABLE 2.10 (continued)

SOLAR EVAPORATION POND 207B (SOUTH)
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS

Compound	Units	207B (South) Liquid		207B (South) Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
MISCELLANEOUS TESTS					
Alkalinity, Total	ppm	NA	860	NA	3000
Conductivity @ 25C	uMHOs	NA	23000	NA	NA
Total Dissolved Solids	ppm	NA	16000	NA	NA
Total Organic Carbon	ppm	NA	297	NA	21000
Total Suspended Solids	%	NA	6.0	NA	NA
pH	units	NA	9.2	NA	NA
METALS					
Aluminum	ppm	NA	ND	NA	1870
Antimony	ppm	NA	ND	NA	ND
Arsenic	ppm	NA	0.0164	NA	ND
Barium	ppm	NA	ND	NA	ND
Beryllium	ppm	NA	NA	NA	NA
Bismuth	ppm	NA	ND	NA	ND
Boron	ppm	NA	2.77	NA	138
Cadmium	ppm	NA	ND	NA	28
Calcium	ppm	NA	18.9	NA	124000
Cerium	ppm	NA	NA	NA	NA
Cesium	ppm	NA	NA	NA	NA
Cobalt	ppm	NA	NA	NA	NA
Chromium, Total	ppm	NA	0.0228	NA	30
Chromium, Hexavalent	ppm	NA	NA	NA	NA
Copper	ppm	NA	0.037	NA	95
Germanium	ppm	NA	NA	NA	NA
Iron	ppm	NA	ND	NA	2530
Lead	ppm	NA	ND	NA	9
Lithium	ppm	NA	2.670	NA	ND
Magnesium	ppm	NA	180	NA	9680
Manganese	ppm	NA	0.0182	NA	107
Mercury	ppm	NA	0.001	NA	ND

TABLE 2.10 (continued)

SOLAR EVAPORATION POND 207B (SOUTH)
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS

Compound	Units	207B (South) Liquid		207B (South) Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
Molybdenum	ppm	NA	0.122	NA	ND
Nickel	ppm	NA	0.040	NA	ND
Niobium	ppm	NA	NA	NA	NA
Phosphorous	ppm	NA	NA	NA	NA
Potassium	ppm	NA	791	NA	7370
Rubidium	ppm	NA	NA	NA	NA
Selenium	ppm	NA	ND	NA	ND
Silicon	ppm	NA	0.952	NA	4320
Silver	ppm	NA	ND	NA	ND
Sodium	ppm	NA	2940	NA	24200
Strontium	ppm	NA	2.37	NA	720
Tantalum	ppm	NA	NA	NA	NA
Tellurium	ppm	NA	NA	NA	NA
Thallium	ppm	NA	ND	NA	ND
Thorium	ppm	NA	NA	NA	NA
Tin	ppm	NA	ND	NA	ND
Titanium	ppm	NA	NA	NA	NA
Tungsten	ppm	NA	NA	NA	NA
Vanadium	ppm	NA	NA	NA	NA
Zirconium	ppm	NA	NA	NA	NA
Zinc	ppm	NA	0.037	NA	126
VOLATILE ORGANICS					
Acetone	ppb	NA	ND	NA	ND
Methylene Chloride	ppb	NA	ND	NA	ND
Tetrachloroethene	ppb	NA	ND	NA	130
SEMIVOLATILE					
Acenaphthene	ppb	NA	ND	NA	ND
Bis(2-ethyl hexyl)phthalate	ppb	NA	ND	NA	ND
4-Chloro-3-methylphenol	ppb	NA	ND	NA	ND
2-Chlorophenol	ppb	NA	ND	NA	ND

TABLE 2.10 (continued)

**SOLAR EVAPORATION POND 207B (SOUTH)
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS**

Compound	Units	207B (South) Liquid		207B (South) Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
1,4-Dichlorobenzene	ppb	NA	ND	NA	ND
2,4-Dinitrotoluene	ppb	NA	ND	NA	ND
Di-n-butyl phthalate	ppb	NA	ND	NA	ND
Fluoranthene	ppb	NA	ND	NA	ND
N-Nitroso-di-propylamine	ppb	NA	ND	NA	ND
Phenol	ppb	NA	ND	NA	ND
Phenols, Total	ppb	NA	NA	NA	NA
Pyrene	ppb	NA	ND	NA	ND
1,2,4-Trichlorobenzene	ppb	NA	ND	NA	ND
PESTICIDES/PCBs					
Atrazine	ppb	NA	13	NA	ND
Diazinon	ppb	NA	ND	NA	ND
Simazine	ppb	NA	ND	NA	ND

References: Rockwell International, 1988a, Solar Evaporation Ponds Closure Plan
Dames and Moore, 1991, A Summary of Chemical Analyses of Sludge and Water

NA -- Not Analyzed

ND -- Not Detected

TABLE 2.11

SOLAR EVAPORATION POND 207C
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS

Compound	Units	207C Liquid		207C Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
ANIONS					
Ammonia	ppm	NA	ND	NA	ND
Bicarbonate	ppm	NA	4000	NA	ND
Carbonate	ppm	NA	25000	NA	ND
Chloride	ppm	NA	18300	NA	5360
Cyanide, Total	ppm	ND-1.9	9650	NA	3200
Fluoride	ppm	NA	ND	NA	22800
Nitrate, N	ppm	0.4-21400	2600	NA	97000
Nitrite	ppm	NA	2500	NA	800
Phosphate, Ortho	ppm	NA	390	NA	ND
Phosphate, Total	ppm	NA	431	NA	1700
Sulfate	ppm	NA	12200	NA	110000
Sulfide	ppm	NA	10	NA	ND
TKN-N	ppm	NA	ND	NA	ND
RADIONUCLIDES					
Americium -241	pCi/l	ND-13000	8.6	NA	1.7
Americium -241	pCi/g	NA	NA	NA	NA
Plutonium -239	pCi/l	210-2100	670	NA	15
Plutonium -239	pCi/g	NA	NA	NA	NA
Uranium -234	pCi/l	NA	2600	NA	5.2
Uranium -234	pCi/g	NA	NA	NA	NA
Uranium -235	pCi/l	NA	120	NA	0.8
Uranium -235	pCi/g	NA	NA	NA	NA
Uranium -238	pCi/l	NA	3900	NA	31
Uranium -238	pCi/g	NA	NA	NA	NA
Uranium	pCi/l	1400-40000	ND	NA	ND
Tritium	pCi/l	ND-6400	ND	NA	NA
Tritium	pCi/g	NA	NA	NA	NA
Gross Alpha	pCi/l	10000-46000	72000	NA	18
Gross Beta	pCi/l	405-44000	170000	NA	420

TABLE 2.11 (continued)

SOLAR EVAPORATION POND 207C
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS

Compound	Units	207C Liquid		207C Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
MISCELLANEOUS TESTS					
Alkalinity, Total	ppm	NA	45000	NA	24000
Conductivity @ 25C	uMHOs	NA	610000	NA	NA
Total Dissolved Solids	ppm	93900-175800	400000	NA	NA
Total Organic Carbon	ppm	NA	54.9	NA	NA
Total Suspended Solids	%	NA	76	NA	NA
pH	ppm	7.7-12.5	10.2	NA	NA
METALS					
Aluminum	ppm	NA	ND	NA	97
Antimony	ppm	NA	ND	NA	ND
Arsenic	ppm	NA	ND	NA	ND
Barium	ppm	NA	ND	NA	ND
Beryllium	ppm	ND-0.6	ND	NA	ND
Bismuth	ppm	NA	ND	NA	ND
Boron	ppm	NA	360	NA	117
Cadmium	ppm	NA	0.312	NA	6
Calcium	ppm	NA	ND	NA	ND
Cerium	ppm	NA	NA	NA	NA
Cesium	ppm	NA	NA	NA	NA
Cobalt	ppm	NA	NA	NA	NA
Chromium, Total	ppm	NA	2.36	NA	18
Chromium, Hexavalent	ppm	NA	NA	NA	NA
Copper	ppm	NA	6.79	NA	6
Germanium	ppm	NA	NA	NA	NA
Iron	ppm	NA	ND	NA	36
Lead	ppm	NA	ND	NA	ND
Lithium	ppm	NA	ND	NA	43
Magnesium	ppm	NA	NA	NA	ND
Manganese	ppm	NA	ND	NA	ND
Mercury	ppm	NA	ND	NA	ND

TABLE 2.11 (continued)

SOLAR EVAPORATION POND 207C
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS

Compound	Units	207C Liquid		207C Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
Molybdenum	ppm	NA	ND	NA	ND
Nickel	ppm	NA	5.09	NA	ND
Niobium	ppm	NA	NA	NA	NA
Phosphorous	ppm	NA	NA	NA	NA
Potassium	ppm	NA	78700	NA	273000
Rubidium	ppm	NA	NA	NA	NA
Selenium	ppm	NA	ND	NA	ND
Silicon	ppm	NA	30.1	NA	422
Silver	ppm	NA	ND	NA	ND
Sodium	ppm	NA	102000	NA	50900
Strontium	ppm	NA	ND	NA	ND
Tantalum	ppm	NA	NA	NA	NA
Tellurium	ppm	NA	NA	NA	NA
Thallium	ppm	NA	ND	NA	ND
Thorium	ppm	NA	NA	NA	NA
Tin	ppm	NA	ND	NA	ND
Titanium	ppm	NA	NA	NA	NA
Tungsten	ppm	NA	NA	NA	NA
Vanadium	ppm	NA	NA	NA	NA
Zirconium	ppm	NA	NA	NA	NA
Zinc	ppm	NA	ND	NA	6
VOLATILE ORGANICS					
Acetone	ppb	NA	43	NA	ND
Methylene Chloride	ppb	NA	ND	NA	ND
Tetrachloroethene	ppb	NA	ND	NA	ND
SEMIVOLATILE					
Acenaphthene	ppb	NA	ND	NA	ND
Bis(2-ethyl hexyl)phthalate	ppb	NA	ND	NA	ND
4-Chloro-3-methylphenol	ppb	NA	ND	NA	ND
2-Chlorophenol	ppb	NA	ND	NA	ND

TABLE 2.11 (continued)

SOLAR EVAPORATION POND 207C
SUMMARY OF LIQUID AND SLUDGE SAMPLING RESULTS

Compound	Units	207C Liquid		207C Sludge	
		1984-1988 Range	1991 Composite	1984-1988 Range	1991 Composite
1,4-Dichlorobenzene	ppb	NA	ND	NA	ND
2,4-Dinitrotoluene	ppb	NA	ND	NA	ND
Di-n-butyl phthalate	ppb	NA	ND	NA	ND
Fluoranthene	ppb	NA	ND	NA	ND
N-Nitroso-di-propylamine	ppb	NA	ND	NA	ND
Phenol	ppb	NA	ND	NA	ND
Phenols, Total	ppb	13-35	NA	NA	NA
Pyrene	ppb	NA	ND	NA	ND
1,2,4-Trichlorobenzene	ppb	NA	ND	NA	ND
PESTICIDES/PCBs					
Atrazine	ppb	NA	ND	NA	ND
Diazinon	ppb	NA	2.8	NA	ND
Simazine	ppb	NA	7.5	NA	ND

References: Rockwell International, 1988a, Solar Evaporation Ponds Closure Plan
Dames and Moore, 1991, A Summary of Chemical Analyses of Sludge and Water

NA -- Not Analyzed

ND -- Not Detected

TABLE 2.12

1989 SOIL SAMPLE PARAMETERS LIST

Metals

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Cesium
Chromium
Cobalt
Copper
Iron
Lead
Lithium
Magnesium
Manganese
Mercury
Molybdenum
Nickel
Potassium
Selenium
Silver
Sodium
Strontium
Thallium
Tin
Vanadium
Zinc

Anions

Nitrate
Nitrate/Nitrite
Sulfide

Radiochemistry

Borings P207889, P207989, P208889,
P208989, P209589, P209689, P209789

Americium -241
Cesium -137
Gross Alpha
Gross Beta
Plutonium -239
Radium -226
Radium -228
Strontium -90
Tritium
Total Uranium
Uranium -233, -234
Uranium -235
Uranium -238

Reference: EG&G Rocky Flats, Inc. RFEDs Database

TABLE 2.13

**SUMMARY OF 1989 SOIL SAMPLING RESULTS FOR SELECTED METALS AND INORGANICS
RANGE OF DETECTION (µg/g)**

Borehole Number	Depth (feet)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper
P207389	3.0-19.3	3760-8840	ND	ND-3.9	48.2-74.5	1.9-2.4	ND	5.4-8.3	7.4-15.2
P207489	0.0-10.0	6490-30400	ND	ND-8.8	40.4-120	1.4-8.7	ND	3.2-81.2	5.3-26.6
P207589	3.0-21.4	7650-11600	ND	ND-17.1	ND-155	2.8-3.2	ND	10.1-11.4	5.8-23.7
P207689	0.0-15.3	7340-8920	ND	ND-4.5	ND-147	2.1-2.7	ND	6.4-7.1	7.0-10.4
P207789	0.0-24.3	6370-10400	ND	ND-5.6	ND-202	1.9-3.0	ND	6.3-8.9	6.3-13.1
P207889	0.0-5.5	7480-32700	ND	2.8-9.9	108-269	2.3-9.1	ND	6.5-28.7	6.1-14.4
P207989	0.0-18.2	7240-11700	ND	ND-7.3	70.1-216	1.9-3.5	ND	7.4-7.7	6.4-35.9
P208889	3.5-15.3	5290-7200	ND	2.6-7.7	59.5-11600	1.5-2.5	ND	5.3-6.1	8.1-15.1
P208989	0.0-14.6	5200-8020	ND	2.6-15.5	76.1-1100	1.5-2.1	ND	5.2-8.8	7.7-12.0
P209089	3.5-17.5	4780-17300	ND	ND-6.8	ND-196	1.4-4.2	ND-60.4	4.6-15	7.3-19.1
P209189	3.0-22.3	4140-15400	ND	2.6-13.6	ND-97.2	2.1-4.5	ND	5.9-14.5	ND-12.0
P209289	0.0-17.8	3240-13200	ND	2.8-6.8	56.3-91	2.6-7.2	ND	7.4-16.3	ND-24.6
P209389	3.0-26.2	2190-12400	ND	ND-5.6	58.2-93	2.5-7.9	ND	4.4-16.1	10.3-14.9
P209489	3.0-21.0	2830-5010	ND	4.3-24.6	ND-76.4	ND-1.7	ND	3.8-6.2	ND-13.8
P209589	0.0-14.5	5360-12900	ND	ND-6.4	ND-97.6	1.4-3.5	ND	4.9-10.4	ND-12.2
P209689	6.2-24.2	9130-8770	ND	ND-12.5	ND-174	2.3-4.1	ND	8.3-10.2	5.9-73.6
P209789	0.0-15.2	5940-7800	ND	ND-2.2	ND-69.4	1.5-2.2	ND	5.6-7.3	ND-8.8
P209889	0.0-15.9	5350-10500	ND	2.5-3.6	45.9-181	1.9-2.9	ND	5.8-9.9	8.7-17.5
P210189	3.0-26.6	6390-23000	ND	ND-3.8	ND-203	ND-1.7	ND	7.6-27.1	ND-24.3
P210289	3.0-19.0	6130-18200	ND	3.1-14.1	ND-254	2.4-5.5	ND	7.2-18.1	7.3-18.0
Upper Tolerance Level* in Background Alluvial Samples		13418	ND	4.3	79.5	4.7	ND	20.0	11.1
Upper Tolerance Level* in Background Bedrock Samples		10428	ND	4.0	121.9	3.4	ND	10.3	16.3

* = Reference: EG&G December 21, 1990, Background Geochemical Characterization Report: Rocky Flats Plant for 1989, Appendix B.

ND = Not Detected above detection limit

NA = Not Analyzed

NC = Upper tolerance level Not Calculated

TABLE 2.13 (continued)

SUMMARY OF 1989 SOIL SAMPLING RESULTS FOR SELECTED METALS AND INORGANICS
RANGE OF DETECTION (µg/g)

Borehole Number	Depth (feet)	Lead	Lithium	Mercury	Nickel	Selenium	Silver	Thallium	Zinc	Nitrate/Nitrate (mg/kg)
P207389	3.0-19.3	ND	19.4-23.5	ND	ND-12.5	ND	ND	ND	27.6-46.5	1.1-5.3
P207489	0.0-10.0	ND	18.4-21.7	ND	ND-37.5	ND	ND-5.8	ND	23.3-62.1	1.2-8.3
P207589	3.0-21.4	5.4-24.6	3.7-18.8	0.46-1.1	ND-42.5	ND	ND-2.9	ND	13.7-124	1.6-21
P207689	0.0-15.3	6.9-13.9	5.1-11.8	ND-0.12	ND	ND	ND	ND	ND-10.1	6.3-8.3
P207789	0.0-24.3	10.5-24.7	3.1-13.6	ND-0.18	ND	ND	ND	ND	ND-29.4	3.6-14
P207889	0.0-5.5	4.7-16.7	9.6-23.9	0.12-0.37	ND-41.7	ND	ND-3.1	ND	10.1-45.3	6.4-8.1
P207989	0.0-18.2	6-8.9	6.7-10.1	0.21-0.25	ND-23.0	ND	ND	ND	ND-93.4	2.5-7.6
P208889	3.5-15.3	9.3-20.3	5.6-5.7	ND	ND	ND	ND	ND	29.2-37.9	1900-3400
P208989	0.0-14.6	2.4-27.5	2.3-3.1	ND	ND-21.1	ND	ND	ND	11.2-56.2	1.4-51
P209089	3.5-17.5	8.6-21.7	2.3-35.8	ND-0.24	9.2-35.7	ND	ND	ND	15.8-101	1.6-182
P209189	3.0-22.3	6.4-14.7	2.3-9.2	ND-0.19	9.2-15.8	ND	ND	ND	12.8-35.9	1.6-180
P209289	0.0-17.8	ND-4.9	18.2-23	ND	11.7-33.5	ND	ND-5.3	ND	21.2-90.9	ND-21
P209389	3.0-26.2	ND-3.1	15.8-22.2	ND	ND-28.9	ND	ND-5.6	ND	28.0-59.8	ND-4.0
P209489	3.0-21.0	9.5-14.5	2.2-3.6	ND	ND-11.3	ND	ND	ND	8.4-35.8	4.0-32
P209589	0.0-14.5	10.3-17.6	4.1-9.1	ND	ND	ND	ND	ND	23.5-40.6	560-1300
P209689	6.2-24.2	6.9-30.9	4.3-10.6	ND-0.44	ND-133	ND	ND-3.7	ND	ND-487	2.2-43
P209789	0.0-15.2	3.9-86.9	5.3-8.9	ND-0.32	ND	ND	5.6-7.3	ND	ND	3.2-12
P209889	0.0-15.9	11.1-30.3	4.4-11.8	ND	ND	ND-2.3	ND	ND	29.0-54.8	630-1400
P210189	3.0-26.6	2.6-14	18.6-22.8	ND	ND-21.9	ND-1.3	ND	ND	12.8-82.6	3.4-420
P210289	3.0-19.0	20.2-31.1	4.1-11.9	ND-0.17	ND-10.5	ND	ND	ND	15.5-66.6	1.2-21
Upper Tolerance Level* in Background Alluvial Samples		12.2	ND	NA	21.4	ND	ND	ND	39.7	NC (Mean = 0.8583)
Upper Tolerance Level* in Background Bedrock Samples		18.6	11.6	NA	20.2	ND	ND	ND	62.3	NC (Mean = 0.8953)

* = Reference: EG&G December 21, 1990, Background Geochemical Characterization Report: Rocky Flats Plant for 1989, Appendix B.

ND = Not Detected above detection limit

NA = Not Analyzed

NC = Upper tolerance level Not Calculated

TABLE 2.14

**SUMMARY OF 1989 SOIL SAMPLING RESULTS FOR RADIONUCLIDES
RANGE OF DETECTION PLUS COUNTING ERROR (pCi/g)**

Borehole Number	Depth (feet)	Cesium -137	Gross Alpha	Gross Beta	Plutonium -239	Radium -226	Strontium -90
P207889	0.0-5.5	0(0.01)	0(7)-10(8)	11(5)-13(5)	0(0.01)-0.02(0.02)	0.5(0.1)-0.7(0.1)	-0.6(0.7)- -0.1(0.4)
P207989	0.0-18.2	0(0.01)	12(9)-29(10)	14(5)-28(6)	0(0.01)	0.7(0.1)-1.3(0.1)	-0.4(0.5)- -0.1(0.5)
P208889	3.5-15.3	0(0.01)	17(9)-28(10)	16(5)-29(6)	0(0.01)	0.7(0.1)-1.1(0.1)	-0.4(0.5)-0(0.6)
P208989	0.0-14.6	0(0.01)	24(14)-37(16)	21(6)-30(6)	0(0.01)-0.01(0.01)	0.7(0.1)-1.1(0.1)	-0.2(0.4)-0.1(0.6)
P209589	0.0-14.5	0(0.01)	17(8)-33(11)	22(5)-29(6)	0(0.01)-0.17(0.03)	0.9(0.1)-1.1(0.1)	-0.3(0.7)- -0.2(0.6)
P209689	6.2-24.2	0(0.01)	14(9)-29(10)	23(6)-32(6)	0(0.01)-0.01(0.02)	0.6(0.1)-1.0(0.1)	-0.4(0.6)-0.1(0.6)
P209789	0.0-15.2	0(0.01)	17(9)-25(10)	23(5)-28(6)	0(0.01)-0.03(0.02)	0.6(0.1)-0.9(0.1)	-0.5(0.5)- -0.1(0.4)
Upper Tolerance Level* in Background Alluvial Samples (pCi/g except Tritium pCi/ml)		0.07	38.36	36.82	0.015	0.65	0.73
Upper Tolerance Level* in Background Bedrock Samples (pCi/g except Tritium pCi/ml)		0.07	48.42	34.15	0.021	1.14	0.67

* = Reference: EG&G December 21, 1990, Background Geochemical Characterization Report: Rocky Flats Plant for 1989, Appendix B.

pCi/g = PicoCuries per gram
pCi/ml = PicoCuries per milliliter
NA = Not Analyzed

TABLE 2.14 (continued)

**SUMMARY OF 1989 SOIL SAMPLING RESULTS FOR RADIONUCLIDES
RANGE OF DETECTION PLUS COUNTING ERROR (pCi/g)**

Borehole Number	Depth (feet)	Tritium (pCi/ml)	Total Uranium	Uranium -233/-234	Uranium -235	Uranium -238
P207889	0.0-5.5	-0.1(0.15)- -0.07(0.15)	0.9-1.3	0.4(0.2)-0.8(0.2)	0(0.1)	0.5(0.1)-0.7(0.2)
P207989	0.0-18.2	-0.08(0.15)-0.79(0.17)	1.2-3.7	0.6(0.2)-1.9(0.4)	0(0.1)-0.1(0.1)	0.6(0.2)-1.7(0.4)
P208889	3.5-15.3	16(1)-36(1)	1.8-2.3	0.7(0.2)-1.2(0.2)	0(0.1)	1.0(0.2)-1.1(0.2)
P208989	0.0-14.6	0.63(0.15)-0.87(0.16)	1.5-2.0	0.4(0.2)-0.8(0.2)	0(0.1)-0.2(0.1)	0.7(0.2)-1.3(0.3)
P209589	0.0-14.5	5.2(0.2)-12(1)	1.4-2.8	0.7(0.2)-1.4(0.3)	0(0.1)-0.1(0.1)	0.7(0.2)-1.3(0.3)
P209689	6.2-24.2	-0.01(0.14)-2.8(0.2)	0.9-1.5	0.5(0.2)-0.7(0.2)	0(0.1)	0.4(0.1)-0.8(0.2)
P209789	0.0-15.2	-0.15(0.15)-1.5(0.2)	0.8-1.6	0.2(0.2)-0.7(0.2)	0(0.1)-0.1(0.1)	0.5(0.2)-0.9(0.2)
Upper Tolerance Level* in Background Alluvial Samples (pCi/g except Tritium pCi/ml)		0.41	NA	0.66	0.07	0.68
Upper Tolerance Level* in Background Bedrock Samples (pCi/g except Tritium pCi/ml)		0.29	NA	0.98	0.18	1.04

* = Reference: EG&G December 21, 1990, Background Geochemical Characterization Report: Rocky Flats Plant for 1989, Appendix B.

pCi/g = PicoCuries per gram

pCi/ml = PicoCuries per milliliter

NA = Not Analyzed

TABLE 2.15

**SUMMARY OF HISTORICAL SOIL SAMPLING RESULTS FOR RADIONUCLIDES
RANGE OF DETECTION PLUS COUNTING ERROR (pCi/g)**

Borehole Number	Depth (feet)	Gross Alpha	Gross Beta	Plutonium -239	Strontium -90
SP0187	23	10(12)-110(20)	8.6(6.1)-39(7)	-0.03(0.13)-18(1)	-0.3(0.6)-0.2(0.4)
SP0287	13	11(14)-21(9)	7.1(5.6)-36(7)	-0.02(0.13)-0.13(0.15)	0.1(0.4)-0.4(0.3)
SP0387	16	21(14)-22(14)	15(6)-21(7)	-0.01(0.14)-0.05(0.15)	-0.1(0.4)-0.1(0.3)
SP0487	32	11(9)-57(13)	12(6)-31(6)	-0.06(0.07)-0.14(0.11)	-0.2(0.5)-0.6(0.6)
SP0587	26	16(12)-48(12)	13(6)-22(6)	-0.02(0.08)-0.13(0.11)	-0.2(0.7)-0.1(0.7)
SP0687	26	14(8)-39(11)	13(5)-30(6)	-0.02(0.07)-0.52(0.16)	-0.2(1.0)-0.6(0.7)
SP0787	26	11(8)-33(11)	11(5)-26(6)	-0.02(0.09)-2.2(0.3)	-0.2(0.7)-0.6(0.9)
SP0887	9	12(12)-32(11)	14(6)-28(6)	-0.01(0.13)-0.03(0.11)	-0.4(0.7)-0.4(0.7)
SP0987	8	18(10)-25(11)	19(6)-28(6)	-0.05(0.07)-0.02(0.09)	-0.2(0.6)-0.1(0.6)
SP1087	24	16(12)-42(16)	17(6)-29(7)	-0.06(0.10)-3.5(0.3)	-0.6(0.7)-1.1(0.9)
SP1187	29	20(10)-38(11)	19(6)-32(6)	-0.06(0.08)-0.05(0.11)	-0.3(0.8)-0.1(0.6)
SP1287	41	9(12)-39(12)	6.6(5.5)-31(7)	-0.05(0.07)-0.03(0.10)	-0.5(0.6)-0.8(0.8)
SP1387	11	16(12)-36(15)	18(6)-29(7)	-0.06(0.09)-0.05(0.12)	-0.4(0.5)-0.5(0.9)
SP1487	4	26(11)-31(12)	20(6)-23(6)	-0.04(0.08)-0.02(0.09)	-0.1(0.6)-0.1(0.7)
SP1587	17	10(9)-31(10)	10(6)-31(6)	-0.04(0.07)-0.04(0.10)	-0.1(0.6)-0.3(0.7)
SP1687	11	23(13)-59(18)	19(6)-31(7)	-0.05(0.14)-9.0(0.6)	-0.4(0.6)-0.0(0.6)
1886	UD	15(9)-27(10)	22(6)-33(-6)	-0.01(0.01)-0.01(0.02)	NA
2086	UD	28(11)-43(13)	17(6)-36(7)	-0.01(0.02)-0.37(0.06)	NA
2286	UD	23(13)-29(14)	25(6)-40(7)	0.0(0.02)-0.06(0.03)	NA
2586	UD	26(11)-46(16)	19(6)-25(6)	0.01(0.02)-0.42(0.05)	NA
2786	UD	23(11)-68(15)	20(6)-46(7)	-0.01(0.02)	NA
Upper Tolerance Level* in Background Alluvial Samples (pCi/g except Tritium pCi/ml)		38.36	36.82	0.015	0.73
Upper Tolerance Level* in Background Bedrock Samples (pCi/g except Tritium pCi/ml)		48.42	34.15	0.021	0.67

* = Reference: EG&G December 21, 1990, Background Geochemical Characterization Report: Rocky Flats Plant for 1989, Appendix B.

NA = Not Analyzed

ND = Not Detected above detection limit

UD = Unknown sample Depth

TABLE 2.15 (continued)

**SUMMARY OF HISTORICAL SOIL SAMPLING RESULTS FOR RADIONUCLIDES
RANGE OF DETECTION PLUS COUNTING ERROR (pCi/g)**

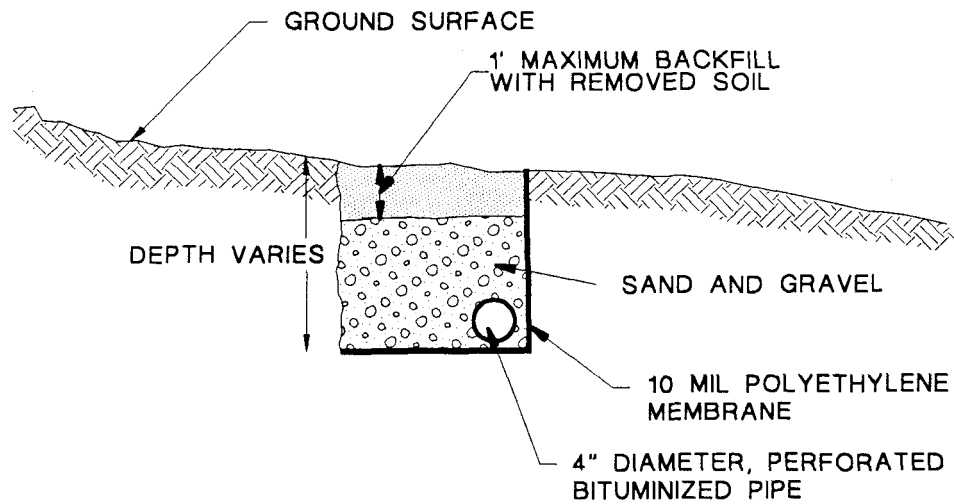
Borehole Number	Depth (feet)	Tritium (pCi/ml)	Uranium -233/-234	Uranium -238	Americium -241
SP0187	23	ND	0.40(0.12)-4(0.6)	0.53(0.13)-2.8(0.5)	0.02(0.06)-2.2(0.2)
SP0287	13	ND	0.26(0.11)-1.5(0.3)	0.19(0.10)-1.2(0.2)	0.01(0.06)-0.22(0.13)
SP0387	16	ND-2(0.3)	0.61(0.18)-0.77(0.18)	0.47(0.17)-0.70(0.18)	0.03(0.07)-0.09(0.12)
SP0487	32	ND-1.3(0.3)	0.52(0.12)-1.6(0.4)	0.66(0.14)-1.3(0.3)	0(0.06)-1.2(0.2)
SP0587	26	ND-3.3(0.3)	0.50(0.13)-1.7(0.2)	0.39(0.11)-1.4(0.2)	0(0.04)-0.13(0.08)
SP0687	26	ND	0.50(0.13)-1.8(0.3)	0.38(0.11)-1.7(0.2)	0.01(0.09)-0.5(0.17)
SP0787	26	ND-2.3(0.3)	0.42(0.11)-1.2(0.2)	0.41(0.11)-1.6(0.2)	-0.06(0.09)-0.61(0.18)
SP0887	9	2.8(0.3)-3.8(0.4)	0.87(0.15)-1.1(0.2)	0.65(0.13)-1.0(0.2)	0.01(0.07)-0.06(0.09)
SP0987	8	ND-0.86(0.28)	0.45(0.12)-0.94(0.18)	0.43(0.11)-1.1(0.2)	0.0(0.06)-0.06(0.08)
SP1087	24	ND-0.65(0.28)	0.45(0.16)-3.7(0.4)	0.58(0.14)-1.4(0.2)	-0.03(0.04)-0.59(0.19)
SP1187	29	ND	0.77(0.21)-1.7(0.2)	0.83(0.21)-1.7(0.2)	-0.04(0.05)-0.02(0.06)
SP1287	41	ND	0.38(0.12)-1.7(0.3)	0.57(0.15)-1.6(0.2)	-0.03(0.04)-0.05(0.06)
SP1387	11	ND	0.66(0.18)-1.7(0.2)	0.93(0.19)-1.5(0.2)	-0.03(0.06)-0.03(0.07)
SP1487	4	ND	0.67(0.14)-0.93(0.17)	0.64(0.14)-1.1(0.2)	-0.06(0.08)-0.03(0.05)
SP1587	17	ND	0.64(0.14)-1.2(0.2)	0.51(0.13)-1.2(0.2)	-0.04(0.09)-0.05(0.10)
SP1687	11	ND	0.49(0.12)-1.1(0.2)	0.55(0.13)-0.78(0.16)	0.0(0.09)-0.96(0.26)
1886	UD	-0.02(0.21)-0.19(0.21)	0.83(0.20)-1.1(0.2)	1.0(0.2)-1.2(0.2)	0(0.01)-0.01(0.02)
2086	UD	0.06(0.21)-3.9(0.3)	0.44(0.15)-1.3(0.2)	1.4(0.3)-2.7(0.3)	0(0.01)-0.30(0.06)
2286	UD	1.7(0.2)-2.0(0.3)	0.71(0.26)-2.0(0.5)	1.2(0.3)-1.8(0.4)	0(0.02)-0.01(0.02)
2586	UD	0.06(0.22)-3.3(0.3)	0.69(0.14)-0.92(0.22)	0.82(0.15)-1.3(0.3)	0(0.01)-0.09(0.04)
2786	UD	1.5(0.2)-11(1)	0.8(0.2)-1.5(0.3)	1.1(0.2)-1.3(0.2)	-0.05(0.06)-0.01(0.02)
Upper Tolerance Level* in Background Alluvial Samples (pCi/g except Tritium pCi/ml)		0.41	0.66	0.68	0.014
Upper Tolerance Level* in Background Bedrock Samples (pCi/g except Tritium pCi/ml)		0.29	0.98	1.04	NA

* = Reference: EG&G December 21, 1990, Background Geochemical Characterization Report: Rocky Flats Plant for 1989, Appendix B.

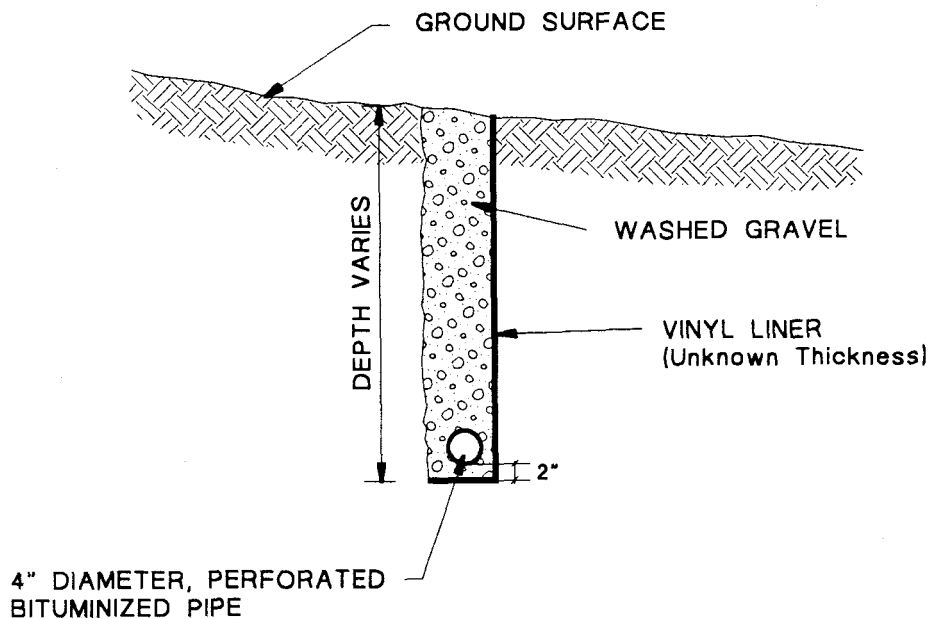
NA = Not Analyzed

ND = Not Detected above detection limit

UD = Unknown sample Depth



CROSS SECTION OF TYPICAL TRENCH AND FRENCH DRAIN
SYSTEM NOT ALONG SEGMENT D-D'
(Not to scale)

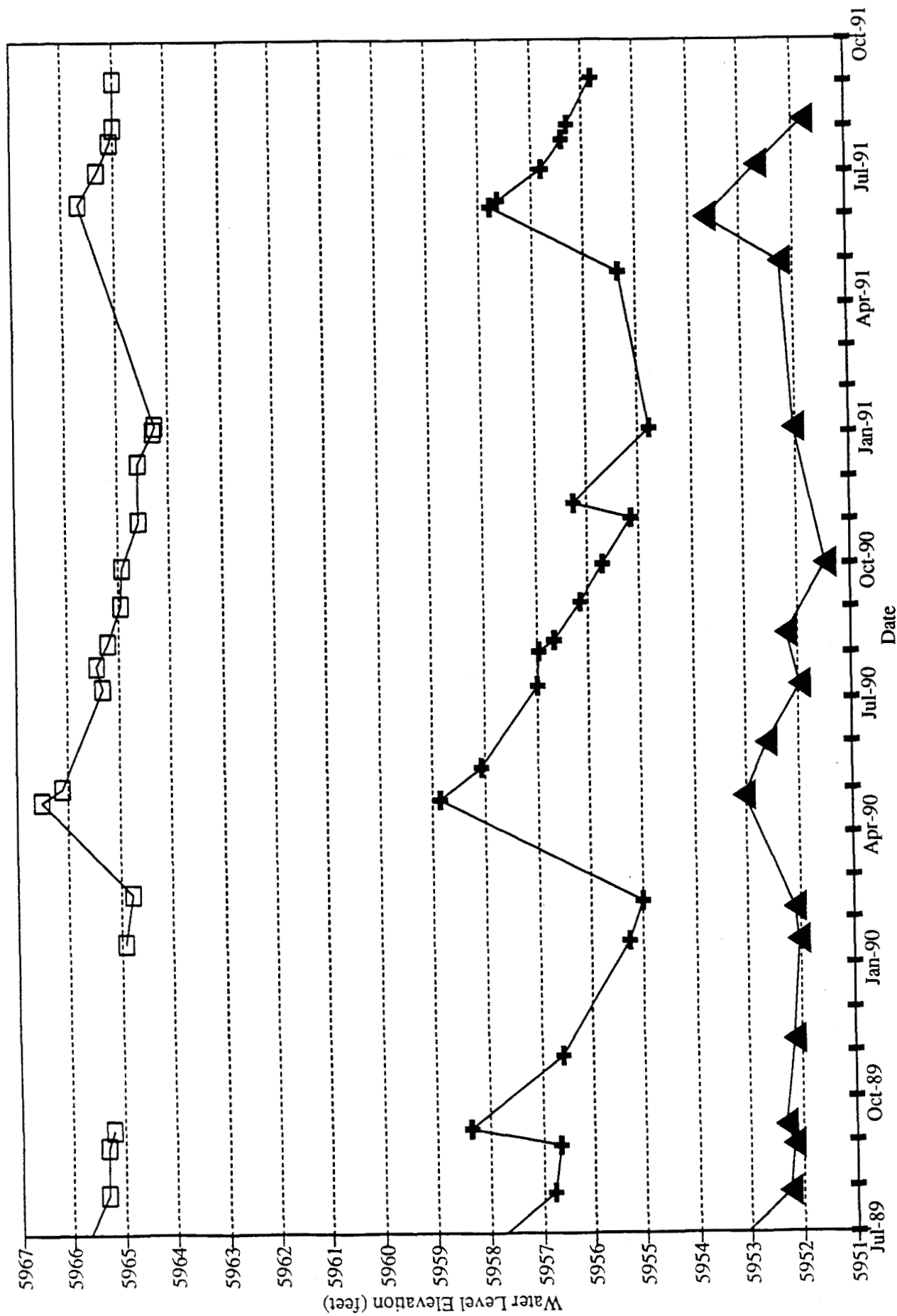


CROSS SECTION OF TYPICAL FRENCH DRAIN ALONG
SEGMENT D-D'
(Not to scale)

PREPARED FOR:			
U.S. DEPARTMENT OF ENERGY			
Rocky Flats Plant Golden, Colorado			
FIGURE 2-8			
TITLE:			
TYPICAL TRENCH AND ITS (FRENCH DRAIN) CROSS SECTIONS			
PROJ. NO.	304909	DWG. NO.	304909-A61
DESIGN BY	G. BRAND	CHECKED	<i>AWB</i>
DRAWN BY	KRONER	APPROVED	
DATE	10-21-91	SCALE	NA
			SHEET
			OF

REFERENCE: MODIFIED AFTER ROCKWELL INTERNATIONAL
SOLAR EVAPORATION POND CLOSURE PLAN,
JULY 1988, VOLUME I, FIGURE 7.

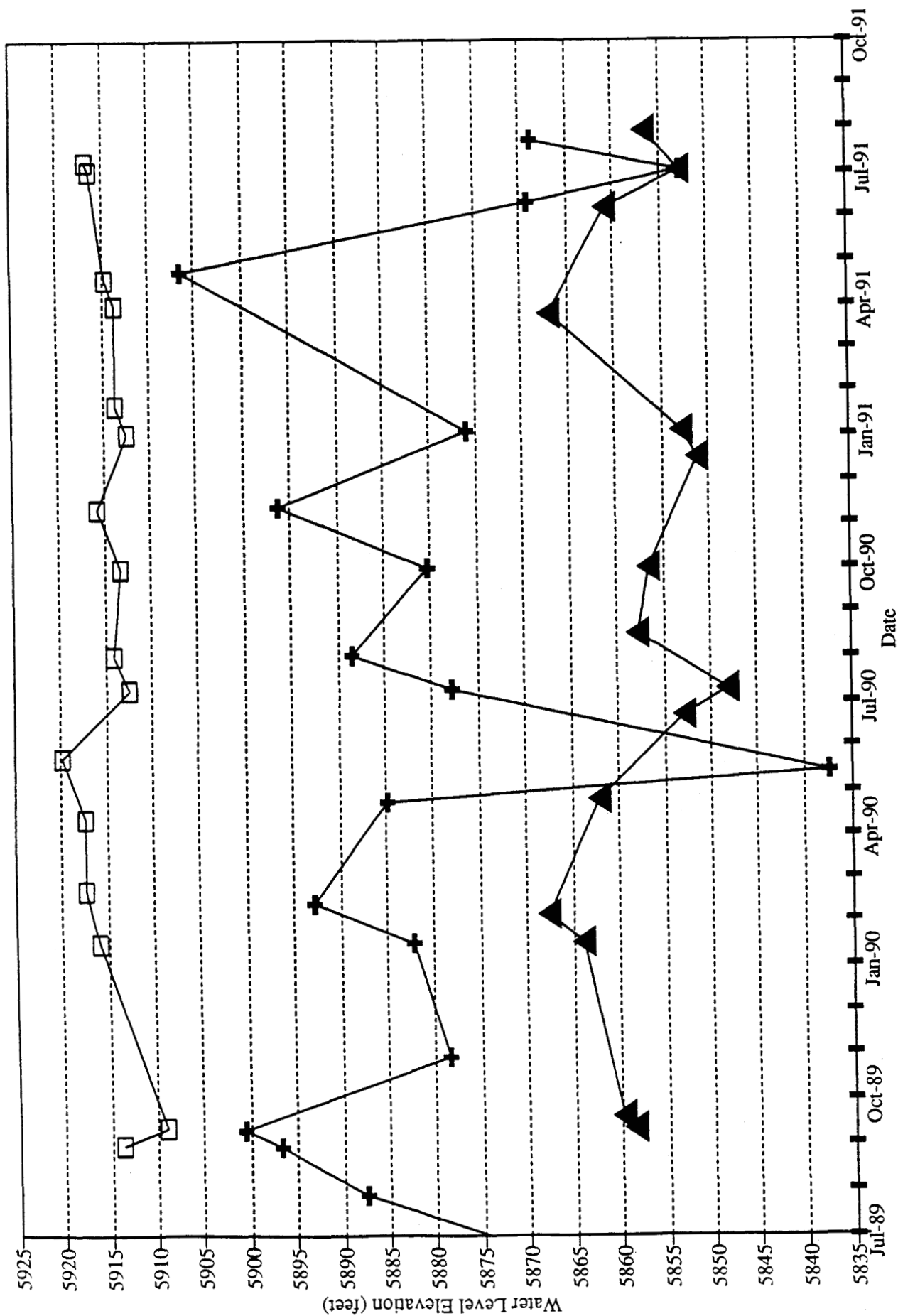
Hydrograph - Alluvial Wells



□ 2686 + 2886 ▲ 3086

FIGURE 2-18

Hydrograph - Bedrock Wells



2786
 B208189
 P208889

REFERENCE: ASI, SOLAR POND INTERCEPTOR
TRENCH SYSTEM GROUND WATER MANAGEMENT
STUDY ZERO-OFFSITE WATER DISCHARGE,
JANUARY 1991, FIGURE 13.

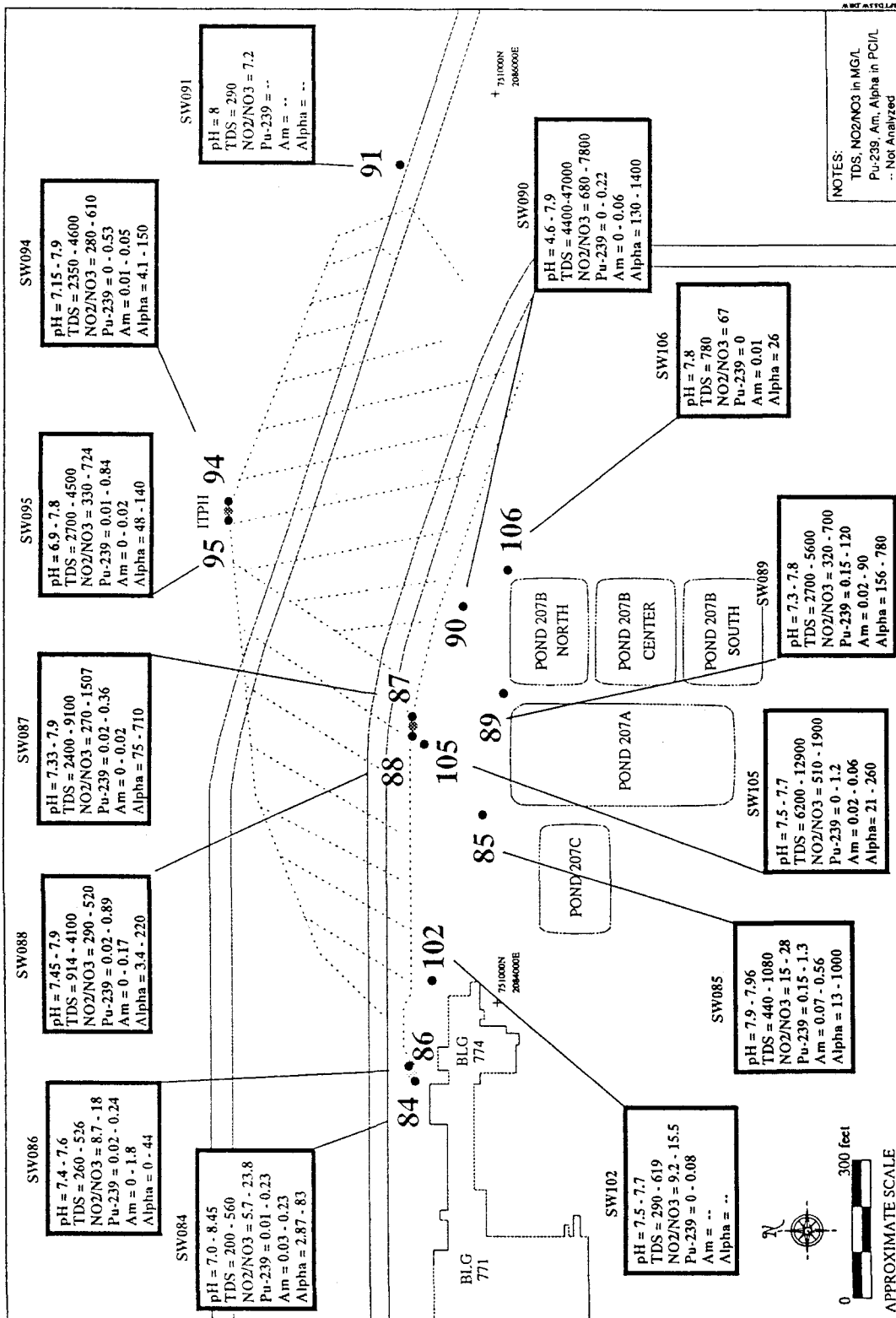
PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 2-28

TITLE: **SURFACE WATER MONITORING LOCATIONS**

INDICATING CONCENTRATIONS OF SELECTED PARAMETERS

PROJ. NO.	DWG. NO.	SHEET
304909	304909-A63	OF
DESIGN BY	CHECKED	APPROVED
DRAWN BY	KRONER	DATE
10-21-91	SCALE	N/A



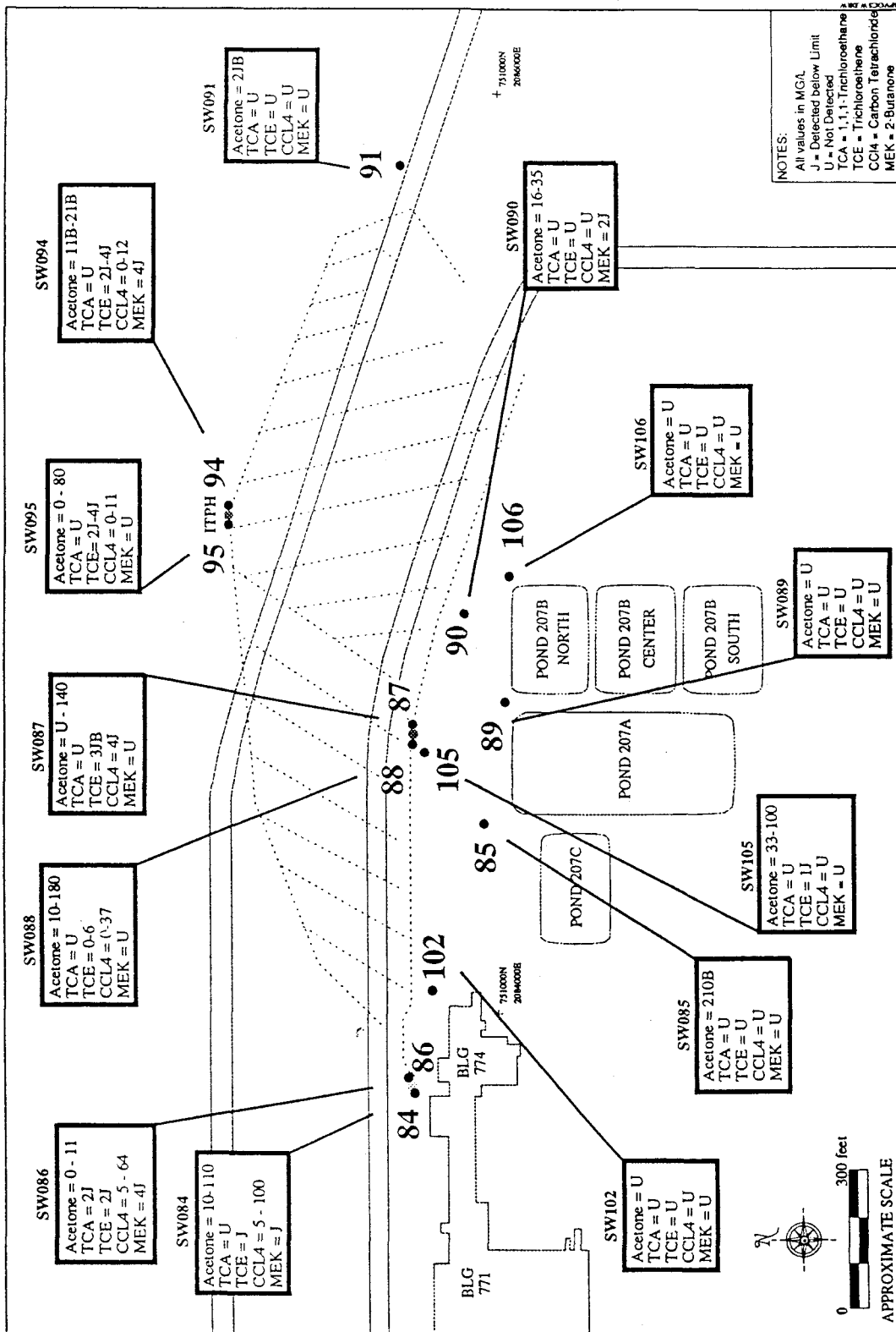
PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 2-28

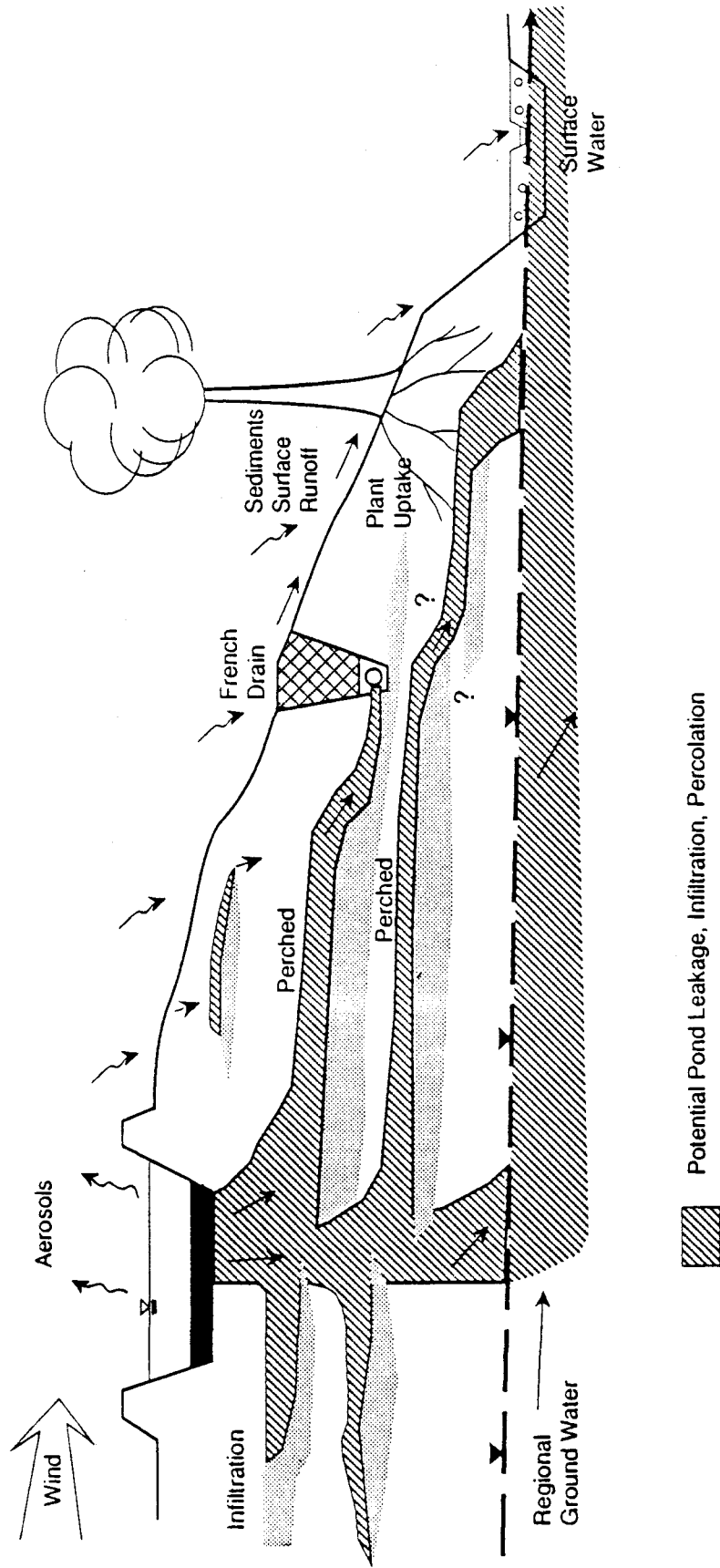
TITLE: **SURFACE WATER MONITORING LOCATIONS**


INDICATING CONCENTRATIONS OF SELECTED PARAMETERS

PROJ. NO.	DWG. NO.	SHEET
304909	304909-A63	OF
DESIGN BY	CHECKED	APPROVED
DRAWN BY	KRONER	DATE
10-21-91	SCALE	N/A



PREPARED FOR:		U.S. DEPARTMENT OF ENERGY	
		Rocky Flats Plant	
		Golden, Colorado	
TITLE:		FIGURE 2-29	
		SURFACE WATER MONITORING	
		LOCATIONS	
		INDICATING CONCENTRATIONS OF	
		SELECTED VOC'S	
PROJ. NO.	304909	DWG. NO.	304909-A62
DESIGN BY	G. BRAND	CHECKED	JJS
DRAWN BY	KRONER	APPROVED	
DATE	10-21-91	SCALE	N/A



 Potential Pond Leakage, Infiltration, Percolation

 Clay Lenses/Layers Restricting Vertical Movement

PREPARED FOR:		U.S. DEPARTMENT OF ENERGY	
		Rocky Flats Plant	
		Golden, Colorado	
TITLE:		FIGURE 2-31	
		POTENTIAL INTERRELATIONSHIPS BETWEEN SOLAR EVAPORATION PONDS, SOIL/VAPOR ZONE AND GROUND WATER SYSTEM	
PROJ. NO.	304908	DWG. NO.	304909-A64
DESIGN BY	G. BRAND	CHECKED	JAL
DRAWN BY	KRONER	APPROVED	
DATE	10-21-91	SCALE	NA
			SHEET
			OF

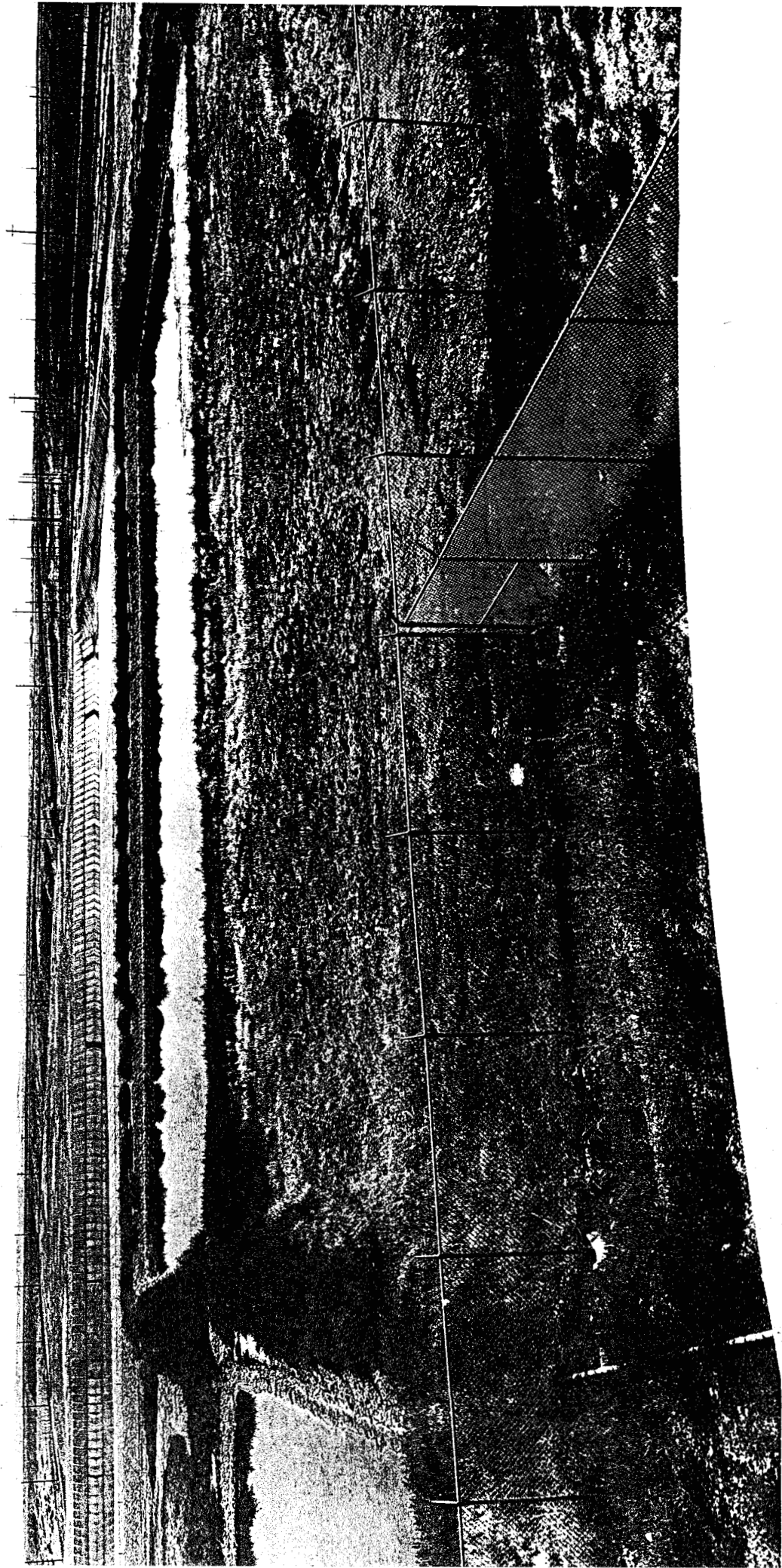


PHOTOGRAPH 2-1
SOLAR EVAPORATION POND AREA FACING SOUTH (JUNE 1991)



PHOTOGRAPH 2-2

SOLAR EVAPORATION POND AREA FACING SOUTHWEST (JUNE 1991)

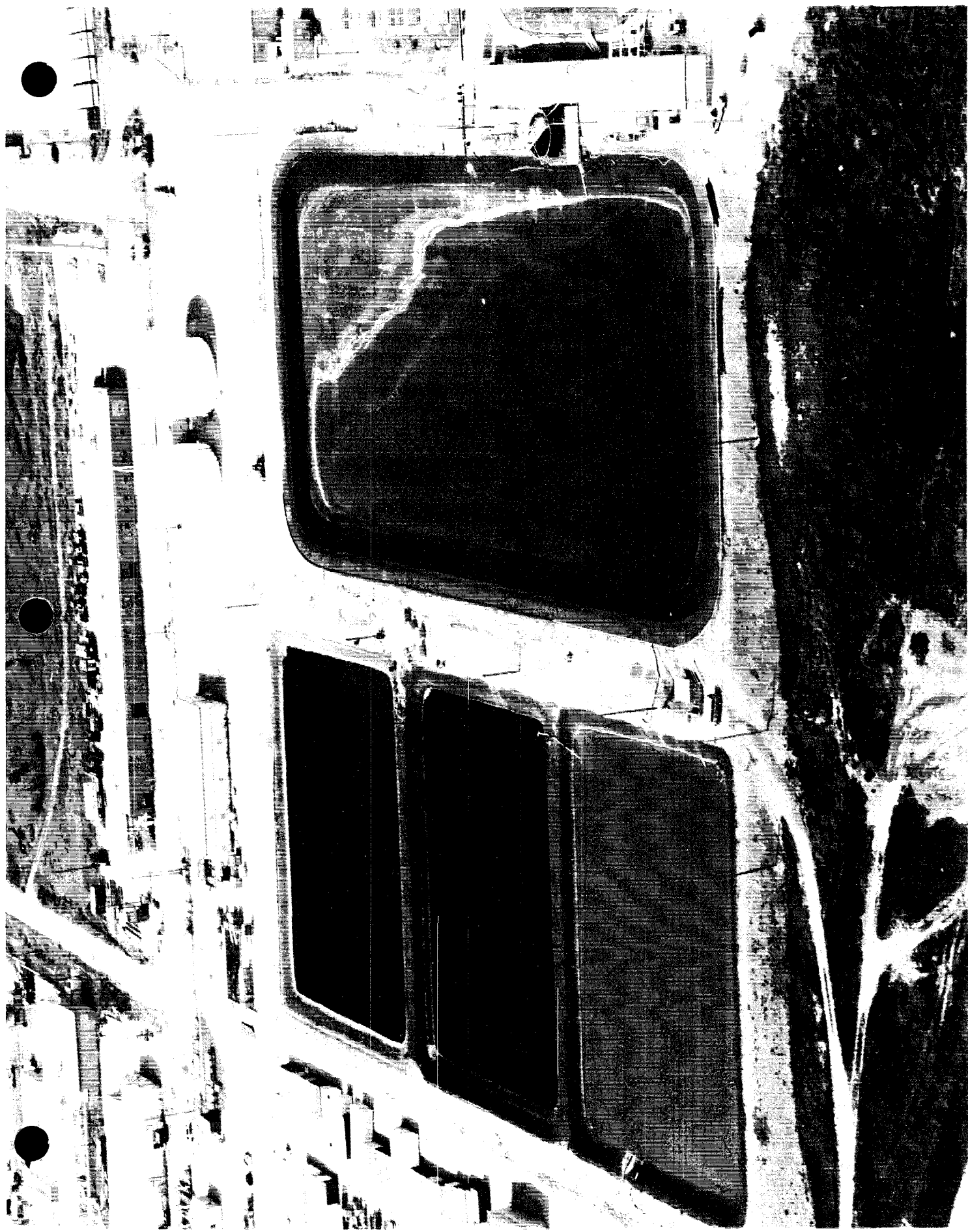


PHOTOGRAPH 2-3
EASTERLY VIEW OF ORIGINAL PONDS WITH POND 207-A IN BACKGROUND (SEPTEMBER 1956)



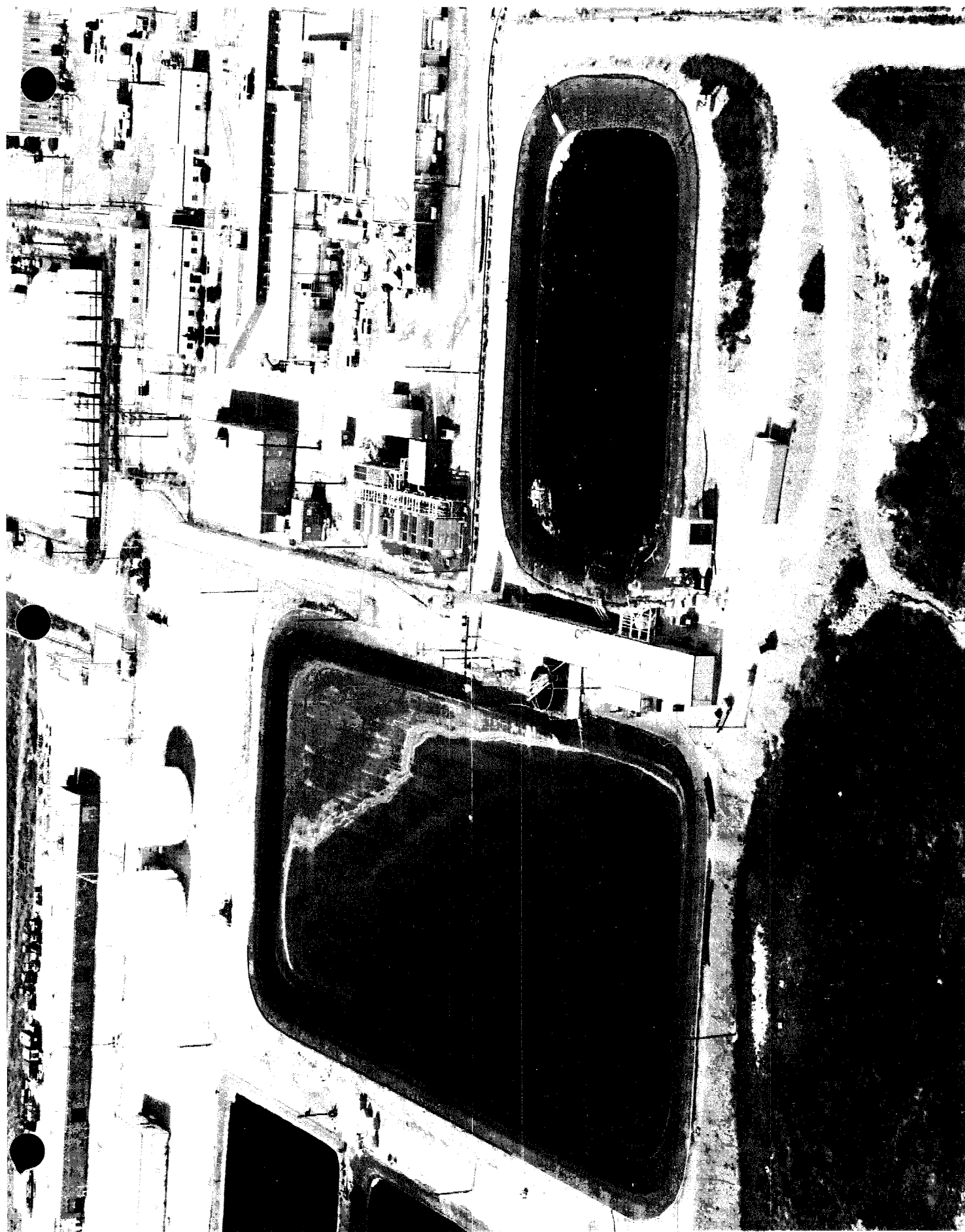
PHOTOGRAPH 2-4

POND 207-A ORIGINAL CONSTRUCTION OF ASPHALT PLANKING (MAY 1956)



PHOTOGRAPH 2-5

POND 207-A AND PONDS 207-B (NORTH, CENTER, SOUTH) FACING SOUTH (JUNE 1991)



PHOTOGRAPH 2-6
POND 207-A AND POND 207-C FACING SOUTH (JUNE 1991)

3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section provides a preliminary identification of potential chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs) for surface water and ground water at OU4. The summary of potential sitewide ARARs presented is based on current federal and state health and environmental statutes and regulations. The ARARs presented are not specific to OU4 because insufficient validated data exist to justify inclusion or exclusion of specific constituents. The preliminary identification and examination of potential ARARs will provide for the use of appropriate analytical detection limits during the RFI/RI. As data become available during the Phase I RFI/RI, specific ARARs will be proposed for OU4. Location-specific ARARs will be addressed in the RFI/RI report. The Corrective Measures Study (CMS)/Feasibility Study (FS) report will further address chemical-specific ARARs as well as action- and location-specific ARARs in the development and evaluation of remedial alternatives.

3.1 THE ARAR BASIS

Section 121 (d) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that Superfund-financed, enforcement, and federal facility remedial actions comply with federal ARARs or more stringent promulgated state requirements. CDH Water Quality Control Commission (WQCC) ground water standards (5 CCR 1002-8, Section 3.12.0) became effective on April 30, 1991, and are therefore considered in the process for developing potential sitewide ARARs for RFP.

3.2 THE ARAR PROCESS

A screening and analysis process will be used to determine which of the potential ARARs will be applied to OU4. The analysis will address compliance with chemical-, location-, and action-specific ARARs in accordance with the National Contingency Plan (NCP). The screening process will consider relevant and appropriate requirements in the same manner as applicable requirements. When more than one ARAR is identified, the more stringent of the applicable ARARs will be used.

The first step in identifying potential ARARs will occur after the initial scoping and site characterization and will involve analysis of the chemicals present at the site and any location-specific characteristics at the site. After the chemicals have been identified, the presence or absence of chemical-specific ARARs will be determined. Chemical-specific ARARs will be derived primarily from federal and state health and environmental statutes and regulations, including the following:

- Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) applicable to both surface water and ground water
- Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) potentially applicable to surface water and alluvial ground water
- RCRA, Part 264, Subpart F, Ground Water Concentration Limits (40 CFR 264.94) applicable to ground water
- CDH-WQCC surface water standards for Woman Creek and Walnut Creek (5 CCR 1002-8, Section 3.8.29, effective March 30, 1990) applicable to surface water
- CDH-WQCC, Basic Standards for Ground Water (5 CCR 1002-8, Section 3.11.0, amended September 1990) potentially applicable to ground water
- CDH-WQCC, Classifications and Water Quality Standards for Ground Water (5 CCR 1002-8, Section 3.12.0, effective April 30, 1991) potentially applicable to ground water.

A summary of chemical-specific standards or potential ARARs (based on the above regulations and contaminants that may be found potentially sitewide) is presented in Table 3-1, "Ground Water Quality Standards," Table 3-2, "Federal Surface Water Quality Standards," and Table 3-3, "State Surface Water Quality Standards." These potential chemical-specific ARARs and accompanying regulations will be screened to determine their jurisdictional requirements and applicability to OU4. If the requirements are not applicable, they will be further screened to determine whether they are relevant and appropriate to the particular site-specific conditions at OU4. Where ARARs do not exist for a particular chemical or where existing ARARs are not protective of human health and the environment, to-be-considered (TBC) criteria (such as guidance, proposed standards, and advisories developed by EPA, other federal agencies, or states) will be evaluated for use. Where ARARs or TBC criteria are not available or are less than laboratory practical quantitation limits (PQLs), PQLs will be used. For any parameters to be analyzed in ground water, surface water, or soil and for which no ARARs or TBCs were found, use of the methods that achieve the detection limits provided in the General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G, 1991j), which are contract laboratory program (CLP) required quantitation limits, should enable meaningful interpretation of sample results. In addition, whenever a potential standard is below the GRRASP-derived detection limit, the detection limit will be used as the standard. Risk-based concentrations taken from the baseline risk assessment will be used in establishing the remediation goals for the parameters for which no potential ARARs could be identified, thus ensuring environmental protectiveness.

3.2.1 ARARs

"Applicable requirements," as defined in 40 CFR 300.5, are "those standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable." "Relevant and appropriate requirements," also defined in 40 CFR 300.5, are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws, that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate." The most stringent promulgated standards are applied as ARARs (Preamble to NCP, 55 FR 8741). According to the NCP (40 FR 300.400(g)(4)), the term "promulgated" means that standards are of general applicability and are legally enforceable.

3.2.2 TBCs

In addition to ARARs, advisories, criteria, or guidance may be identified as TBC for a particular release. As defined in 40 CFR 300.400(g)(3), the TBC category consists of advisories, criteria, or guidance developed by EPA, other federal agencies, or states that may be useful in developing remedies. Use of TBCs is discretionary rather than mandatory, as is the case with ARARs.

3.2.3 ARAR Categories

In general, there are three categories of ARARs:

1. Ambient or chemical-specific requirements
2. Location-specific requirements
3. Performance, design, or other action-specific requirements

ARARs are generally considered to be dynamic in nature in that they evolve from general to very specific in the CERCLA site cleanup process. Initially, during the RFI/RI work plan stage, probable chemical-specific ARARs may be identified, usually on the basis of limited data. Chemical-specific ARARs at this point have meaning only in that they can be used to ensure that appropriate detection

limits have been established so that data collected in the RFI/RI will be amenable for comparison to ARAR standards. It is also appropriate to identify location-specific ARARs early in the RFI/RI process so that information can be gathered to determine whether restrictions can be placed on the concentrations of hazardous substances or on the conduct of an activity solely because it occurs in a special location. As discussed in the introductory paragraph of this section, detailed, location-specific ARARs will be proposed in the RFI/RI report. Identification of action-specific ARARs and remediation goals is part of the feasibility study process and will be addressed in the CMS/FS report. Chemical-specific ARARs may be deleted if they are found to be inappropriate at any time in the RFI/RI process. Deletion of chemical-specific ARARs will be based on analytical information obtained from sampling at OU4.

One medium for which chemical-specific ARARs do not currently exist is soils; however, some chemical-related, action-specific requirements do exist, such as Colorado's construction standard for plutonium in soils. Relative to chemical-specific ARARs, a risk assessment will be performed to determine acceptable contaminant concentrations in soils to ensure environmental "protectiveness." At this time, with respect to establishing analytical detection limits for soil, use of method detection limits provided in GRRASP (EG&G, 1991j), which are CLP required quantitation limits, should enable meaningful interpretation of soil sample results.

For appropriate management of investigation-derived wastes, as required in the IAG, (Attachment 2, Statement of Work, Section IV) DOE has developed standard operating procedures (SOPs) for field investigation activities. All waste generated by the various investigations conducted at RFP will follow SOPs approved by EPA and CDH. The SOPs satisfy the IAG requirement to comply with ARARs as they relate to investigation activities. This approach is consistent with EPA policy as provided in the *Draft Guide to Management of Investigation-Derived Waste* (U.S. EPA, 1991a).

3.2.4 Remedial Action

CERCLA Section 121 specifically requires attainment of all ARARs. Moreover, as explained in the preamble to the NCP (55 FR 8741), in order to attain all ARARs, a remedial action must comply with the most stringent requirement, which then ensures attainment of all other ARARs. Furthermore, CERCLA requires that the remedies selected attain ARARs and be protective of human health and the environment. Remediation goals will be based on the baseline risk assessment to be conducted for protection of human health and the environment.

TABLE 3.1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUND WATER QUALITY STANDARDS (ug/l)

FEDERAL STANDARDS					STATE STANDARDS											
Parameter	Type (5)	PQL MDL (6)	Method (6)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	CDH/CWQCC Ground Water Quality Standards (d)							
									Statewide		Site-Specific (g)				Table 5 Chronic	Table 6 Radionuclides Woman Creek
									Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS			
Bicarbonate	A	10	E310.1													
Carbonate	A	10	E310.1													
Chloride	A	5	E325	250,000 *												
Chlorine	A	1000	E4500													
Fluoride	A	5	E340	4,000; 2,000*		4,000					2,000					
N as Nitrate	A	5	E353.1	10,000			10,000				100,000					
N as Nitrate+Nitrite	A	5	E353.1				10,000				10,000					
N as Nitrite	A	5	E354.1				1,000									
Sulfate	A	5	E375.4	250,000*							250,000					
Sulfide	A															
Coliform (total)	B	1	SM9221C	1/100 ml												
Ammonia as N	C	5	E350													
Dioxin	D		d						0.00000022 (7)						0.000000013	
Sulfur	E	100,000	E600													
Dissolved Oxygen	FP	0.5	SM4500													
pH	FP	0.1	E150.1	6.5-8.5 *							6.5-8.5					
Specific Conductance	FP	1	E120.1													
Temperature	FP															
Boron	I	5	E6010													
Total Dissolved Solids	I	10	E160.1	500,000*									400,000 (1)			
Aluminum	M	200	CT	50 to 200*												
Antimony	M	60	CT													
Arsenic	M	10	CT	50				50								
Arsenic III	M															

TABLE 3.1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUND WATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS					STATE STANDARDS						
Parameter	Type (5)	PQL MDL	Method (6)	SDWA	SDWA	SDWA	SDWA	RCRA	CDH/CW/QCC Ground Water Quality Standards (d)						
				Maximum Contaminant Level TBCs	Maximum Contaminant Level TBCs	Maximum Contaminant Level TBCs	Maximum Contaminant Level TBCs	Subpart F Concentration Limit (40CFR264.94) (c)	Statewide Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6
				(e)	(b)	(a)	(b)	(c)	(d)						Radionuclides Woman Walnut Creek
Arsenic V	M	200	CT	1,000	2,000 (e)			1,000		1,000					
Barium	M	5	CT									100			
Beryllium	M	5	CT	10	5			10		10		10			
Cadmium	M	5,000	CT												
Calcium	M	1,000	NC												
Cesium	M	10	CT	50	100			50		50		100			
Chromium	M	5	SW8467196												
Chromium III	M	10	E218.5												
Chromium VI	M	50	CT									50			
Cobalt	M	25	CT	1,000 *				1300 (f)		200		1,000			
Copper	M	10	CT									200			
Cyanide	M	100	CT	300 *						50		300			
Iron	M	5	CT	50				0 (f)				5,000			
Lead	M	100	NC									100			
Lithium	M	5000	CT									2,500			
Magnesium	M	15	CT	50 *											
Manganese	M	0.2	CT	2	2			2		2		50			
Mercury	M	200	NC									200			
Molybdenum	M	40	CT									10			
Nickel	M	5000	CT									200			
Potassium	M	5	CT	10	50			10		10		20			
Selenium	M	10	CT	50	100 *			50		50					
Silver	M	5000	CT												
Sodium	M	200	NC												
Strontium	M	10	CT												
Thallium	M	200	NC												
In															

TABLE 3.1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUND WATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS				STATE STANDARDS									
Parameter	Type (5)	PQL MDL	Method (6)	SDWA	SDWA	SDWA	SDWA	RCRA	CDH/CWQCC Ground Water Quality Standards (d)								
				Maximum Contaminant Level TBCs (a)	Maximum Contaminant Level TBCs (b)	Maximum Contaminant Level Goals TBCs (a)	Maximum Contaminant Level Goals TBCs (b)	Subpart F Concentration Limit (40CFR264.94) (c)	Statewide Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman Walnut Creek		
Titanium	M	10	E6010														
Tungsten	M	10	E6010														
Vanadium	M	50	CT														
Zinc	M	20	CT	5,000 *													
2,4,5-TP Silvex	P		d	10	50			10	50	10	10						
2,4-Dichlorophenoxyacetic Acid (2,4-D)	P		d	100	70			100	70	100	100		100				
Aldicarb	P				3 (e)			1 (e)		10	10						
Aldrin	P	0.05	CP							0.002 (7)	0.0000784						
Bromacil	P																
Carbofuran	P		d		40			40		36							
Chloranil	P																
Chlordane (Alpha)	P	0.5	CP		2			0		0.03 (7)	0.00046						
Chlordane (Gamma)	P	0.5	CP		2			0		0.03 (7)	0.00046						
Chlorpyrifos	P		E619														
DDT	P	0.1	CP							0.1 (7)	0.000024						
DDT Metabolite (DDD)	P	0.1	CP														
DDT Metabolite (DDE)	P	0.1	CP														
Demeton	P																
Diazinon	P																
Dieldrin	P	0.1	CP							0.002 (7)	0.000071						
Endosulfan I	P	0.05	CP														
Endosulfan II	P	0.1	CP														
Endosulfan sulfate	P	0.1	CP														
Endrin	P	0.1	CP	0.2						0.2	0.2						
Endrin Ketone	P	0.1	CP														

TABLE 3.1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUND WATER QUALITY STANDARDS (ug/l)

			FEDERAL STANDARDS					STATE STANDARDS						
			SDWA Maximum Contaminant Level TBCs	SDWA Maximum Contaminant Level TBCs	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94)	Statewide Tables A & B (d)	CDH/CWQCC Ground Water Quality Standards (d)					
									Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides
Parameter	Type (5)	PQL MDL	Method (6)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides					
									Woman	Walnut Creek				
Guthion	P	0.05	CP	0.4	0	0.008 (7)		0.00028						
Heptachlor	P	0.05	CP	0.2	0	0.004 (7)		0.0092						
Hexachlorocyclohexane, Alpha	P	0.05	CP					0.0163						
Hexachlorocyclohexane, Beta	P	0.05	CP					0.0123						
Hexachlorocyclohexane, Delta	P	0.05	CP					0.0186						
Hexachlorocyclohexane, Technical	P		f											
Hexachlorocyclohexane, Lindane	P	0.05	CP	0.2	0.2	4								
Malathion	P													
Methoxychlor	P	0.5	CP	40	40	100	100							
Mirex	P													
Parathion	P													
PCBs	P	0.5	CP	0.5	0	0.005 (7)		0.000079						
Simazine	P		e					4.0						
Toxaphene	P	1	CP	3	0	5	5							
Vapontite 2	P													
Aroclor 1016	PP	0.5	CP											
Aroclor 1221	PP	0.5	CP											
Aroclor 1232	PP	0.5	CP											
Aroclor 1242	PP	0.5	CP											
Aroclor 1248	PP	0.5	CP											
Aroclor 1254	PP	1	CP											
Aroclor 1260	PP	1	CP					3.0						
Atrazine	PP		e	3	3					0.05				
Americium (pCi/l)	R									0.05				
Americium 241 (pCi/l)	R	0.01												

TABLE 3.1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUND WATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS				STATE STANDARDS							
				SDWA Maximum Contaminant Level TBCs	SDWA Maximum Contaminant Level TBCs	SDWA Maximum Contaminant Level Goals	RCRA Subpart F Concentration Limit (40CFR264.94)	Statewide Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides	
	Type (5)	PQL MDL	Method (6)	(a)	(b)	(c)	(d)							Woman Creek	Walnut Creek
Parameter														80	80
Cesium 134 (pCi/l)	R	1						80 (2)							
Cesium 137 (pCi/l)	R	1													
Gross Alpha (pCi/l)	R	2		15 (8)					15					7	11
Gross Beta (pCi/l)	R	4		50 (4 mrem/yr)					4 mrem/yr					5	19
Plutonium 238+239+240 (pCi/l)	R	0.01						15 (2)						0.05	0.05
Plutonium (pCi/l)	R							5 (2)							
Radium 226+228 (pCi/l)	R	0.5/1.0 (4)		5											
Strontium 89+90 (pCi/l)	R	1		8 (3)				8 (2)						8	8
Strontium 90 (pCi/l)	R							60 (2)							
Thorium 230+232 (pCi/l)	R			20,000 (3)				20,000 (2)						500	500
Tritium (pCi/l)	R														
Uranium 233+234 (pCi/l)	R														
Uranium 235 (pCi/l)	R	0.6													
Uranium 238 (pCi/l)	R	0.6													
Uranium (Total) (pCi/l)	R														
1,2,4,5-Tetrachlorobenzene	SV		b					2 (7)							10
1,2,4-Trichlorobenzene	SV	10	CS												
1,2-Dichlorobenzene (Ortho)	SV	10	CS	600				620							
1,2-Diphenylhydrazine	SV		b					0.05 (7)							
1,3-Dichlorobenzene (Meta)	SV	10	CS		75			620							
1,4-Dichlorobenzene (Para)	SV	10	CS					75							
2,4,5-Trichlorophenol	SV	50	CS					700							
2,4,6-Trichlorophenol	SV	10	CS					2 (7)					1.2		
2,4-Dichlorophenol	SV	10	CS					21							
2,4-Dimethylphenol	SV	10	CS												
2,4-Dinitrophenol	SV	50	CS												

TABLE 3.1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUND WATER QUALITY STANDARDS (ug/l)

Parameter	Type (5)	PQL MDL	Method (6)	FEDERAL STANDARDS					STATE STANDARDS					
				SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Statewide Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman Walnut Creek Creek
				(a)	(b)	(b)	(c)	(d)						
2,4-Dinitrotoluene	SV	10	CS											
2-Chloronaphthalene	SV	10	CS											
2-Chlorophenol	SV	10	CS											
2-Methylnaphthalene	SV	10	CS											
2-Methylphenol	SV	10	CS											
2-Nitroaniline	SV	50	CS											
2-Nitrophenol	SV	10	CS											
3,3-Dichlorobenzidine	SV	20	CS											
3-Nitroaniline	SV	50	CS											
4,6-Dinitro-2-methylphenol	SV	50	CS											
4-Bromophenyl Phenylether	SV	10	CS											
4-Chloroaniline	SV	10	CS											
4-Chlorophenyl Phenyl Ether	SV	10	CS											
4-Chloro-3-methylphenol	SV	10	CS											
4-Methylphenol	SV	10	CS											
4-Nitroaniline	SV	50	CS											
4-Nitrophenol	SV	50	CS											
Acenaphthene	SV	10	CS											
Anthracene	SV	10	CS											
Benzidine	SV	50	d					0.0002 (7)	0.1				0.00012	
Benzoic Acid	SV	50	CS											
Benzo(a)anthracene	SV	10	CS											
Benzo(a)pyrene	SV	10	CS											
Benzo(b)fluoranthene	SV	10	CS											
Benzo(g,h,i)perylene	SV	10	CS											
Benzo(k)fluoranthene	SV	10	CS											
Benzyl Alcohol	SV	10	CS											

TABLE 3.1
POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCs (October 1, 1991)
GROUND WATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS					STATE STANDARDS								
				SDWA Maximum Contaminant Level TBCs	SDWA Maximum Contaminant Level TBCs	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level TBCs (a)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Statewide Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides	
Parameter	Type (5)	PQL MDL	Method (6)	(a)	(b)	(a)	(b)	(a)	(c)	(d)	1						Woman Creek
bis(2-Chloroethoxy)methane	SV	10	CS							0.03 (7)						0.0000037	
bis(2-Chloroethyl)ether	SV	10	CS														
bis(2-Chloroisopropyl)ether	SV	10	CS														
bis(2-Ethylhexyl)phthalate	SV	10	CS														
Butadiene	SV	10	CS														
Butylbenzylphthalate	SV	10	CS														
Chlorinated Ethers	SV																
Chlorinated Naphthalenes	SV																
Chloroalkylethers	SV	10	CS														
Chlorophenol	SV																
Chrysene	SV	10	CS														
Dibenzofuran	SV	10	CS														
Dibenz(a,h)anthracene	SV	10	CS														
Dichlorobenzenes	SV																
Dichlorobenzidine	SV	20	CS												0.01		
Diethylphthalate	SV	10	CS														
Dimethylphthalate	SV	10	CS														
Dinitrotoluene	SV	10	CS														
Di-n-butylphthalate	SV	10	CS														
Di-n-octylphthalate	SV	10	CS														
Ethylene Glycol	SV		d							7,000							
Fluoranthene	SV	10	CS														
Fluorene	SV	10	CS														
Formaldehyde	SV																
Haloethers	SV																
Hexachlorobenzene	SV	10	CS							0.02 (7)						0.000072	
Hexachlorobutadiene	SV	10	CS							14						0.45	

TABLE 3.1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUND WATER QUALITY STANDARDS (ug/l)

					FEDERAL STANDARDS					STATE STANDARDS							
Parameter	Type	PQL MDL	Method (6)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Statewide Tables A & B (d)	CDH/CWQCC Ground Water Quality Standards (d)					Table 6 Radionuclides Woman Creek		
										Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic			
Hexachlorocyclopentadiene	SV	10	CS					(e)	49								
Hexachloroethane	SV	10	CS														
Hydrazine	SV																
Indeno(1,2,3-cd)pyrene	SV	10	CS														
Isophorone	SV	10	CS						1,050								
Naphthalene	SV	10	CS														
Nitrobenzene	SV	10	CS														
Nitrophenols	SV																
Nitrosamines	SV																
Nitrosodibutylamine	SV		b														
Nitrosodiethylamine	SV		b														
Nitrosodimethylamine	SV		b														
Nitrosopyrrolidine	SV		b														
N-Nitrosodiphenylamine	SV	10	CSb														
N-Nitroso-di-n-dipropylamine	SV	10	CSb														
Pentachlorinated Ethanes	SV		b														
Pentachlorobenzene	SV		b														
Pentachlorophenol	SV	50	CS		1 (e)												
Phenanthrene	SV	10	CS														
Phenol	SV	10	CS														
Phthalate Esters	SV		b														
Polynuclear Aromatic Hydrocarbons	SV																
Vinyl Chloride	SV	10	CV	2		0											
1,1,1-Trichloroethane	V	5	CV	200		200											
1,1,2,2-Tetrachloroethane	V	5	CV														
1,1,2-Trichloroethane	V	5	CV														

TABLE 3.1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUND WATER QUALITY STANDARDS (ug/l)

[illegible]

TABLE 3.1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUND WATER QUALITY STANDARDS (ug/l)

FEDERAL STANDARDS					STATE STANDARDS											
Parameter	Type	PQL MDL	Method	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Statewide Tables A & B (d)	CDH/CWQCC Ground Water Quality Standards (d)						
										Site-Specific (g)						
										Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman Walnut Creek	
Dichloroethenes	V															
Ethyl Benzene	V	5	CV d		700 0.05		700 0		680 0.0004							
Ethylene Dibromide	V															
Ethylene Oxide	V															
Halomethanes	V															
Methylene Chloride	V	5	CV	100					100							
Pyrene	V	10	CS													
Styrene	V	5	CV		100											
Tetrachloroethanes	V	5	CV													
Tetrachloroethene	V	5	CV		5		0		10							
Toluene	V	5	CV		1,000		1,000		2,420							
Trichloroethanes	V	5	CV													
Trichloroethene	V	5	CV				0									
Vinyl Acetate	V	10	CV						5							
Xylenes (total)	V	5	CV		10,000		10,000									

TABLE 3.1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUND WATER QUALITY STANDARDS (ug/l)

GROUND WATER QUALITY STANDARDS (ug/l)

STATE STANDARDS

FEDERAL STANDARDS

Parameter	Type (5)	PQL MDL	Method (6)	SDWA Maximum Contaminant Level TBCs	SDWA Maximum Contaminant Level TBCs	SDWA Maximum Contaminant Level TBCs	SDWA Maximum Contaminant Level TBCs	RCRA Subpart F Concentration Limit (40CFR264.94)	CDH/CWQCC Ground Water Quality Standards (d)					
				(a)	(b)	(c)	(d)	(e)	Statewide Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic

EXPLANATION OF TABLE

* = secondary maximum contaminant level; TBCs

** = total trihalomethanes: chloroform, bromoform, bromodichloromethane, dibromochloromethane

CDH = Colorado Department of Health

CLP = Contract Laboratory Program

EPA = Environmental Protection Agency

pCi/l = picocuries per liter

PCB = polychlorinated biphenyl

PQL = Practical Quantitation Limit

RCRA = Resource Conservation and Recovery Act

SDWA = Safe Drinking Water Act

TAL = Target Analyte List

THM = Total Trihalomethanes

TIC = Tentatively Identified Compound

MDL = Minimum Detection Limit for radionuclides (pCi/l)

ug/l = micrograms per liter

VOA = Volatile Organic Analysis

WQCC = Water Quality Control Commission

which ever is least restrictive

* = secondary maximum contaminant level; TBCs
** = total trihalomethanes: chloroform, bromoform, bromodichloromethane, dibromochloromethane

CDH = Colorado Department of Health
CLP = Contract Laboratory Program
EPA = Environmental Protection Agency
pCi/l = picocuries per liter
PCB = polychlorinated biphenyl
PQL = Practical Quantitation Limit
RCRA = Resource Conservation and Recovery Act
SDWA = Safe Drinking Water Act
TAL = Target Analyte List
THM = Total Trihalomethanes
TIC = Tentatively Identified Compound
MDL = Minimum Detection Limit for radionuclides (pCi/l)
ug/l = micrograms per liter
VOA = Volatile Organic Analysis
WQCC = Water Quality Control Commission

(1) TDS standard - see Table 4 in (d); standard is 400 mg/l or 1.25 times the background level, whichever is least restrictive
(2) radionuclide standards - see sec. 3.11.5(c)2 in (d)
(3) If both strontium-90 and tritium are present, the sum of their annual dose equivalents to bone marrow shall not exceed 4 mrem/yr.

(4) MDL for Radium 226 is 0.5; MDL for radium 228 is 1
(5) type abbreviations are: A=anion; B=bacteria; C=cation; D=dioxin; E=element; FP=field parameter; I=indicator; M=metal; P=pesticide; PP=pesticide/PCB; R=radionuclide; SV=semi-volatile; V=volatile
(6) method abbreviations are: CT=CLP-TAL; NC=non-CLP; CV=CLP-VOA; CS=CLP-SEMI; EP=EPA-PEST; CP=CLP-PEST; E=EPA; a = detected as total in CV; b = detected as TICs in CS; c = detected as TIC in CV;
d = not routinely monitored; e = monitored in discharge ponds; f = mixture-individual isomers detected.

TABLE 3.1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUND WATER QUALITY STANDARDS (ug/l)

	Type (5)	PQL MDL (6)	Method (6)	FEDERAL STANDARDS					STATE STANDARDS						
				SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	CDH/CWQCC Ground Water Quality Standards (d)						
									Statewide Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman/Walnut Creek

(7) Standard is below (more stringent than) PQL, therefore PQL is standard.

(8) Value for gross alpha excludes uranium.

(a) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of 5/1990)

(b) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142, 143, Final Rule, Effective July 30, 1992 (56 FR 3526; 1/30/1991)

(c) NCP, 40 CFR 300; NCP Preamble 55 FR 8764; CERCLA Compliance with Other Laws Manual, EPA/540/G-89/006, August 1988

(d) CDH/Water Quality Control Commission, The Basic Standards for Ground Water, 3.11.0 (5 CCR 1002-8) 1/5/1987 amended 9/11/1990

(e) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142, 143, Final Rule, Effective January 1, 1993 (56 FR 30266; 7/1/1991)

(f) EPA Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper, 40 CFR 141 and 142 (56 FR 26460; 6/7/91) effective 11/6/91.

(g) CDH/Water Quality Control Commission, Classifications and Water Quality Standards for Ground Water, 3.12.0 (3/5/1991).

TABLE 3.2
POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c)	CWA AWQC for Protection of Human Health TBCs (c)	Fish Consumption Only
Bicarbonate	A	10	E310.1							
Carbonate	A	10	E310.1							
Chloride	A	5	E325	250,000*				860,000(e) 19	230,000(e) 11	4,000
Chlorine	A	1000	E4500							
Fluoride	A	5	E340	4,000; 2,000*						
N as Nitrate	A	5	E353.1	10,000	10,000	10,000	10,000		10,000	
N as Nitrate+Nitrite	A	5	E353.1							
N as Nitrite	A	5	E354.1		1,000	1,000	1,000			
Sulfate	A	5	E375.4	250,000*						
Sulfide	A									
Coliform (Fecal)	B	1	SM9221C							
Ammonia as N	C	5	E350					Criteria are pH and temperature 0.01	0.00000013	0.000000014
Dioxin	D		d							
Sulfur	E	100,000	E600							
Dissolved Oxygen	FP	0.5	SM4500					5,000		
pH	FP	0.1	E150.1	6.5-8.5 *					6.5-9	
Specific Conductance	FP	1	E120.1					SS	SS	
Temperature	FP							SS	SS	
Boron	I	5	E6010					SS	250,000	
Total Dissolved Solids	I	10	E160.1	500,000*						
Aluminum	M	200	CT		50 to 200*			750	87	45,000
Antimony	M	60	CT					9,000	1,600	.0175
Arsenic	M	10	CT	50				360	190	
Arsenic III	M							850	48	
Arsenic V	M									
Barium	M	200	CT	1,000	2,000 (f)		2,000 (f)		1,000	.117**
Beryllium	M	5	CT					130	.0068**	

TABLE 3.2
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (C)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c) Acute Value	CWA AWQC for Protection of Human Health TBCs (c) Chronic Value	CWA AWQC for Protection of Human Health TBCs (c) Water and Fish Ingestion	CWA AWQC for Protection of Human Health TBCs (c) Fish Consumption Only
Cadmium	M	5	CT	10	5	5	5	3.9 (3)	1.1 (3)	10	
Calcium	M	5,000	CT								
Cesium	M	1,000	NC								
Chromium	M	10	CT	50	100	100	100	1,700	210	170,000	3,433,000
Chromium III	M	5	SW8467196					16	11	50	
Chromium VI	M	10	E218.5								
Cobalt	M	50	CT	1,000*				18 (3)	12 (3)		
Copper	M	25	CT				1,300 (f)	22	5.2	200	
Cyanide	M	10	CT						1,000	300	
Iron	M	100	CT	300 *			0 (g)	82 (3)	3.2 (3)	50	
Lead	M	5	CT	50							
Lithium	M	100	NC								
Magnesium	M	5000	CT							50	100
Manganese	M	15	CT	50 *			2	2.4	0.012	0.144	0.146
Mercury	M	0.2	CT	2	2						
Molybdenum	M	200	NC					1,400 (3)	160 (3)	13.4	100
Nickel	M	40	CT								
Potassium	M	5000	CT								
Selenium	M	5	CT	10	50	50	50	20 (d)	5 (d)	10	
Silver	M	10	CT	50	100 *			4.1 (3)	0.12	50	
Sodium	M	5000	CT								
Strontium	M	200	NC								
Thallium	M	10	CT					1,400 (1)	40 (1)	13	48
Tin	M	200	NC								
Titanium	M	10	E6010								
Tungsten	M	10	E6010								
Vanadium	M	50	CT								
Zinc	M	20	CT	5,000 *				120 (3)	110 (3)		

TABLE 3.2
POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA		SDWA		SDWA		CWA		CWA		CWA	
				Maximum Contaminant Level (a)	Maximum Contaminant Level TBCs (b)	Maximum Contaminant Level TBCs (a)	Maximum Contaminant Level TBCs (b)	Maximum Contaminant Level TBCs (a)	Maximum Contaminant Level TBCs (b)	Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only	AWQC for Protection of Human Health TBCs (c)	
2,4,5-TP Silvex	P		d	10	50			50							
2,4-Dichlorophenoxyacetic Acid (2,4-D)	P		d	100	70			70							
Aldicarb	P	0.05	CP		3 (f)			1 (f)		3.0		0.00074	0.00079		
Aldrin	P														
Bromacil	P		d		40			40							
Carbofuran	P														
Chloranil	P	0.5	CP		2			0		2.4	0.0043	0.00046	0.00048		
Chlordane (Alpha)	P	0.5	CP		2			0		2.4	0.0043	0.00046	0.00048		
Chlordane (Gamma)	P		E619							0.063	0.041				
Chlorpyrifos	P	0.1	CP							1.1	0.0011	0.000024	0.000024		
DDT	P	0.1	CP							0.06					
DDT metabolite (DDD)	P	0.1	CP							1.050	0.1				
DDT metabolite (DDE)	P	0.1	CP												
Demeton	P														
Diazinon	P	0.1	CP							2.5	0.0019	0.00007	0.000076		
Dieldrin	P	0.05	CP							0.22	0.056	74	159		
Endosulfan I	P	0.1	CP												
Endosulfan II	P	0.1	CP												
Endosulfan Sulfate	P	0.1	CP							0.18	0.0023	1			
Endrin	P	0.1	CP	0.2											
Endrin Ketone	P	0.1	CP												
Guthion	P	0.05	CP		0.4			0		0.52	0.01	0.00028	0.00029		
Heptachlor	P	0.05	CP		0.2			0			0.0038				
Heptachlor Epoxide	P	0.05	CP												
Hexachlorocyclohexane, Alpha	P	0.05	CP									0.0092	0.031		
Hexachlorocyclohexane, Beta	P	0.05	CP									0.0163	0.0547		
Hexachlorocyclohexane, Delta	P	0.05	CP												
Hexachlorocyclohexane, Technical	P	0.05	f												
Hexachlorocyclohexane, (Lindane) Gamma	P	0.05	CP	4	0.2			0.2		2.0	0.08	0.0123	0.0414		

TABLE 3.2
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	POL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA		CWA		CWA	
								Aquatic Life TBCs (c)	Chronic Value	Aquatic Life TBCs (c)	Chronic Value	Human Health TBCs (c)	Fish Consumption Only
Malathion	P	0.5	CP	100	40		40		0.01		100		
Methoxychlor	P								0.03				
Mirex	P								0.001				
Parathion	P	0.5	CP		0.5		0	0.065	0.013	0.000079**	0.000079**	0.000079**	
PCBs	P		e					2.0	0.014				
Simazine	P	1	CP		3		0	0.73	0.0002			0.00071**	0.000073**
Toxaphene	P												
Vaponite 2	PP	0.5	CP										
Aroclor 1016	PP	0.5	CP										
Aroclor 1221	PP	0.5	CP										
Aroclor 1232	PP	0.5	CP										
Aroclor 1242	PP	0.5	CP										
Aroclor 1248	PP	0.5	CP										
Aroclor 1254	PP	1	CP										
Aroclor 1260	PP	1	CP										
Atrazine	PP		e		3		3						
Americium (pCi/l)	R												
Americium 241 (pCi/l)	R	0.01											
Cesium 134 (pCi/l)	R	1											
Cesium 137 (pCi/l)	R	1											
Gross Alpha (pCi/l)	R	2											
Gross Beta (pCi/l)	R	4											
Plutonium (pCi/l)	R												
Plutonium 238+239+240 (pCi/l)	R	0.01											
Radium 226+228 (pCi/l)	R	0.5/0.1 (9)											
Strontium 89+90 (pCi/l)	R	1											
Strontium 90 (pCi/l)	R												
Thorium 230+232 (pCi/l)	R												

TABLE 3.2
POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA	SDWA	SDWA	SDWA	CWA	CWA	CWA	AWQC for Protection of		
				Maximum Contaminant Level (a)	Maximum Contaminant Level TBCs (b)	Maximum Contaminant Level TBCs (b)	Maximum Contaminant Level TBCs (b)	Acute Value	Chronic Value	Human Health TBCs (c)	AWQC for Protection of Human Health TBCs (c)		
Tritium (pCi/l)	R			20,000 (6)									
Uranium 233+234 (pCi/l)	R												
Uranium 235 (pCi/l)	R	0.6											
Uranium 238 (pCi/l)	R	0.6											
Uranium (total) (pCi/l)	R												
1,2,4,5-Tetrachlorobenzene	SV		b									38	48
1,2,4-Trichlorobenzene	SV	10	CS										
1,2-Dichlorobenzene (Ortho)	SV	10	CS		600				270 (1)				
1,2-Diphenylhydrazine	SV		b										
1,3-Dichlorobenzene (Meta)	SV	10	CS				75						
1,4-Dichlorobenzene (Para)	SV	10	CS										
2,4,5-Trichlorophenol	SV	50	CS	75								2,800	3.6 **
2,4,6-Trichlorophenol	SV	10	CS									1.2 **	
2,4-Dichlorophenol	SV	10	CS						2,020 (1)	970 (1)		3,090	
2,4-Dimethylphenol	SV	10	CS						2,120 (1)	365 (1)			
2,4-Dinitrophenol	SV	50	CS										
2,4-Dinitrotoluene	SV	10	CS									0.11 **	9.1 **
2-Chloronaphthalene	SV	10	CS										
2-Chlorophenol	SV	10	CS										
2-Methylnaphthalene	SV	10	CS						4,360 (1)	2,000 (1)			
2-Methylphenol	SV	10	CS										
2-Nitroaniline	SV	50	CS										
2-Nitrophenol	SV	10	CS										
3,3-Dichlorobenzidine	SV	20	CS									0.01	0.02
3-Nitroaniline	SV	50	CS										
4,6-Dinitro-2-methylphenol	SV	50	CS										
4-Bromophenyl Phenylether	SV	10	CS										
4-Chloroaniline	SV	10	CS										

TABLE 3.2
POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c)	CWA AWQC for Protection of Human Health TBCs (c)	Fish Consumption
4-Chlorophenyl Phenyl Ether	SV	10	CS							
4-Chloro-3-methylphenol	SV	10	CS					30 (1)		
4-Methylphenol	SV	10	CS							
4-Nitroaniline	SV	50	CS					230 (1)		
4-Nitrophenol	SV	50	CS					1,700 (1)		
Acenaphthene	SV	10	CS							
Anthracene	SV	10	CS					2,500	0.00012	0.00053
Benzidine	SV	50	d							
Benzoic Acid	SV	10	CS							
Benzo(a)anthracene	SV	10	CS							
Benzo(a)pyrene	SV	10	CS							
Benzo(b)fluoranthene	SV	10	CS							
Benzo(g,h,i)perylene	SV	10	CS							
Benzo(k)fluoranthene	SV	10	CS							
Benzyl Alcohol	SV	10	CS							
bis(2-Chloroethoxy)methane	SV	10	CS							
bis(2-Chloroethyl)ether	SV	10	CS						0.03**	1.36**
bis(2-Chloroisopropyl)ether	SV	10	CS						34.7	4,360
bis(2-Ethylhexyl)phthalate	SV	10	CS						15,000	50,000
Butadiene	SV	10	CS							
Butylbenzylphthalate	SV	10	CS							
Chlorinated Ethers	SV	10	CS							
Chlorinated Naphthalenes	SV	10	CS					1,600 (1)		
Chloroalkylethers	SV	10	CS					238,000 (1)		
Chlorophenol	SV	10	CS							
Chrysene	SV	10	CS							
Dibenzofuran	SV	10	CS							
Dibenz(a,h)anthracene	SV	10	CS					1,120 (1)	400	2,600
Dichlorobenzenes	SV	10	CS							

TABLE 3.2
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c)		CWA AWQC for Protection of Human Health TBCs (c)	
								Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only
Dichlorobenzidine	SV	20	CS							0.01	0.02
Diethylphthalate	SV	10	CS							350,000	1,800,000
Dimethylphthalate	SV	10	CS							313,000	2,900,000
Dinitrotoluene	SV	10	CS					330 (1)	230 (1)	70	14,300
Di-n-butylphthalate	SV	10	CS								
Di-n-octylphthalate	SV	10	CS								
Ethylene Glycol	SV	10	d					3,980 (1)		42	54
Fluoranthene	SV	10	CS								
Fluorene	SV	10	CS								
Formaldehyde	SV							380 (1)	122 (1)		
Haloethers	SV	10	CS							0.00072**	0.00074**
Hexachlorobenzene	SV	10	CS					90 (1)	9.3 (1)	0.45**	50 **
Hexachlorobutadiene	SV	10	CS					7 (1)	5.2 (1)	206	
Hexachlorocyclopentadiene	SV	10	CS					980 (1)	540 (1)	1.9	8.74
Hexachloroethane	SV	10	CS								
Hydrazine	SV										
Indeno(1,2,3-cd)pyrene	SV	10	CS					117,000 (1)		5,200	520,000
Isophorone	SV	10	CS					2,300 (1)	620 (1)	19,800	
Naphthalene	SV	10	CS					27,000 (1)			
Nitrobenzene	SV	10	CS					230 (1)	150 (1)		
Nitrophenols	SV							5,850 (1)			
Nitrosamines	SV										
Nitrosodibutylamine	SV		b							0.0064	0.587
Nitrosodiethylamine	SV		b							0.0008	1.24
Nitrosodimethylamine	SV		b							0.0014	16
Nitrosopyrrolidine	SV		b							0.016	91.9
N-Nitrosodiphenylamine	SV	10	b							4.9 **	16.1 **
N-Nitroso-di-n-dipropylamine	SV	10	b								
Pentachlorinated Ethanes	SV		b					7,240 (1)	1,100 (1)		

TABLE 3.2
POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c)		CWA AWQC for Protection of Human Health TBCs (c)		Fish Ingestion	Fish Consumption Only
								Acute Value	Chronic Value	Water and Fish			
Pentachlorobenzene	SV	50	b		1 (f)		0 (f)	20 (4)	13 (4)		74	85	
Pentachlorophenol	SV	10	CS								1,010		
Phenanthrene	SV	10	CS					10,200 (1)	2,560 (1)		3,500		
Phenol	SV		c					940 (1)	3 (1)				
Phthalate Esters	SV		b			0				0.0028**	0.0311**		
Polynuclear Aromatic Hydrocarbons	SV		b							2 **	525 **		
Vinyl Chloride	SV	10	CV	2									
1,1,1-Trichloroethane	V	5	CV	200		200				18,400	1,030,000		
1,1,2,2-Tetrachloroethane	V	5	CV						2,400	0.17**	10.7 **		
1,1,2-Trichloroethane	V	5	CV						9,400	0.6**	41.8 **		
1,1-Dichloroethane	V	5	CV			7							
1,1,1-Dichloroethane	V	5	CV	7		0							
1,2-Dichloroethane	V	5	CV	5				118,000	20,000	0.94**	243 **		
1,2-Dichloroethene (cis)	V		a		70								
1,2-Dichloroethene (total)	V	5	CV										
1,2-Dichloroethene (trans)	V	5	a		100								
1,2-Dichloropropane	V	5	CV		5			23,000	5,700				
1,3-Dichloropropene (cis)	V	5	CV					6,060	244 (1)		87	14,100	
1,3-Dichloropropene (trans)	V	5	CV					6,060	244 (1)		87	14,100	
2-Butanone	V	10	CV										
2-Hexanone	V	10	CV										
4-Methyl-2-pentanone	V	10	CV										
Acetone	V	10	CV										
Acrylonitrile	V		c	5		0		7,500	2,600	0.058	0.65		
Benzene	V	5	CV					5,300		0.66**	40 **		
Bromodichloromethane	V	5	CV										
Bromoform	V	5	CV										
Bromomethane	V	10	CV										

TABLE 3.2
POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA		CWA		AWQC for Protection of Human Health TBCs (c)
								Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only	
Carbon Disulfide	V	5	CV	5	0	0	0	35,200 (1)	50 (1)	0.4**	6.94 **	
Carbon Tetrachloride	V	5	CV					250 (1)				
Chlorinated Benzenes	V	10	CV/CS									
Chlorobenzene	V	5	CV/CS		100		100					
Chloroethane	V	10	CV					28,900 (1)	1,240 (4)	0.19 **	15.7 **	
Chloroform	V	5	CV									
Chloromethane	V	10	CV									
Dibromochloromethane	V	5	CV									
Dichloroethenes	V	5	CV					11,600 (1)		0.033**	1.85 **	
Ethyl Benzene	V	5	CV		700		700	32,000 (1)		1,400	3,280	
Ethylene Dibromide	V		d		0.05		0					
Ethylene Oxide	V							11,000 (1)		0.19**	15.7 **	
Halomethanes	V	5	CV	100								
Methylene Chloride	V	10	CS									
Pyrene	V	5	CV		100		100					
Styrene	V	5	CV					9,320 (1)				
Tetrachloroethanes	V	5	CV		5		0	5,280 (1)	840 (1)	0.80**	8.85 **	
Tetrachloroethene	V	5	CV		1,000		1,000	17,500 (1)		14,300	424,000	
Toluene	V	5	CV					18,000 (1)				
Trichloroethanes	V	5	CV					45,000 (1)				
Trichloroethene	V	5	CV	5		0						
Vinyl Acetate	V	10	CV							2.7 **	80.7 **	
Xylenes (total)	V	5	CV		10,000		10,000					

EXPLANATION OF TABLE

* = secondary maximum contaminant level, TBCs

** = Human health criteria for carcinogens reported for three risk levels. Value presented is the 10-5 risk level.

AWQC = Ambient Water Quality Criteria

TABLE 3.2
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA	SDWA	SDWA	SDWA	SDWA	CWA	CWA	CWA
				Maximum Contaminant Level (a)	Maximum Contaminant Level (b)	Maximum Contaminant Level TBCs (b)	Maximum Contaminant Level Goals TBCs (a)	Maximum Contaminant Level Goals TBCs (b)	AWQC for Protection of Aquatic Life TBCs (c)	AWQC for Protection of Human Health TBCs (c)	
									Acute Value	Chronic Value	Water and Fish Ingestion

CLP = Contract Laboratory Program

CWA = Clean Water Act

EPA = Environmental Protection Agency

pCi/l = picocuries per liter

PCB = polychlorinated biphenyl

PQL = Practical Quantitation Level

SDWA = Safe Drinking Water Act

SS = Species Specific

TAL = Target Analyte List

THM = Total Trihalomethanes

TIC = Tentatively Identified Compound

MDL = Minimum Detection Limit for radionuclides (pCi/l)

ug/l = micrograms per liter

VOA = Volatile Organic Analysis

(1) criteria not developed; value presented is lowest observed effects level (LOEL)

(2) total trihalomethanes: chloroform, bromoform, bromodichloromethane, dibromochloromethane

(3) hardness dependent criteria

(4) pH dependent criteria (7.8 pH used)

(5) standard is not adequately protective when chloride is associated with potassium, calcium, or magnesium, rather than sodium.

(6) if both strontium-90 and tritium are present, the sum of their annual dose equivalents to bone marrow shall not exceed 4 mrem/yr.

(7) type abbreviations are: A=anion; B=bacteria; C=cation; D=dioxin; FP=field parameter; I=indicator; M=metal; P=Pesticide; PP=Pesticide/PCB; R=radionuclide; SV=semi-volatile; V=volatile

(8) method abbreviations are: CT=CLP-TAL; NC=non-CLP; CV=CLP-VOA; CS=CLP-SEMI; EP=EPA-PEST; CP=CLP-PEST; E=EPA; a = detected as total in CV; b = detected as TIC in CS;

c = detected as TIC in CV; d = not routinely monitored; e = monitored in discharge ponds; f = mixture-individual isomers detected.

(9) MDL for radium 226 is 0.5; MDL for radium 228 is 1.0

(10) Value for gross alpha excludes uranium

(a) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of May 1990). Segment 4 MCLs are ARAR; Segment 5 MCLs are TBC; all MCLGs are TBC.

(b) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142 and 143, Final Rule (56 FR 3526; 1/30/91) effective July 30, 1992.

TABLE 3.2
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c)		CWA AWQC for Protection of Human Health TBCs (c)	
								Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only

- (c) EPA, Quality Criteria for Protection of Aquatic Life, 1986
(d) EPA, National Ambient Water Quality Criteria for Selenium - 1987
(e) EPA, National Ambient Water Quality Criteria for Chloride - 1988
(f) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142, and 143, Final Rule (56 FR 30266; 7/1/1991) effective 1/1/1993.
(g) EPA Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper, 40 CFR 141 and 142 (56 FR 26460; 6/7/1991) effective 11/6/1991.

TABLE 3.3
POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

				Statewide Standards (a)										Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)				
Parameter	Type (10)	PQL MDL	Method (11)	Tables A,B Carcinogens/ Noncarcinogens (2)		Table C Aquatic Life		Tables I,II,III (1)				Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (8)		Table 2 Radionuclides	
				Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Acute Value	Chronic Value	Agricul- tural Standard (3)	Domestic Water Supply (6)	Aquatic Life	Water Supply				Acute Value	Chronic Value	Woman Creek	Walnut Creek
Bicarbonate	A	10	E310.1																	
Carbonate	A	10	E310.1																	
Chloride	A	5	E325																	
Chlorine	A	1000	E4500	3	3															
Fluoride	A	5	E340																	
N as Nitrate	A	5	E353.1																	
N as Nitrate+Nitrite	A	5	E353.1																	
N as Nitrite	A	5	E354.1																	
Sulfate	A	5	E375.4																	
Sulfide	A																			
Coliform (Fecal)	B	1	SM9221C																	
Ammonia as N	C	5	E350																	
Dioxin	D		d	0.00000022 (13)	0.01	0.00001								0.00000022 (13)	0.000000013			60	0.000000013	
Sulfur	E	100,000	E600																	
Dissolved Oxygen	FP	0.5	SM4500																	
pH	FP	0.1	E150.1																	
Specific Conductance	FP	1	E120.1																	
Temperature	FP																			
Boron	I	5	E6010																	
Total Dissolved Solids	I	10	E160.1																	
Aluminum	M	200	CT																	
Antimony	M	60	CT																	
Arsenic	M	10	CT																	
Arsenic III	M																			
Arsenic V	M																			
Mercury	M	200	CT																	

TABLE 3.3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

				Statewide Standards (a)										Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)				
Parameter	Type (10)	PQL MDL	Method (11)	Tables A,B Carcinogens/Noncarcinogens (2)	Table C Aquatic Life		Tables I,II,III (1)				Organics (12)	Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radionuclide	Stream Segment Table (8)		Table 2 Radionuclides			
					Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (6)					Aquatic Life	Water Supply	Acute Value	Chronic Value	Woman Creek	Walnut Creek
Beryllium	M	5	CT																	
Cadmium	M	5	CT			TVS				100						TVS				
Cadmium	M	5,000	CT							10										
Calcium	M	1,000	NC																	
Cesium	M	10	CT																	
Chromium	M	5	SW8467196																	
Chromium III	M	10	E218.5																	
Chromium VI	M	10	CT																	
Cobalt	M	50	CT																	
Copper	M	25	CT																	
Copper	M	10	CT			TVS				100						TVS				
Cyanide	M	100	CT			5				200						TVS				
Iron	M	100	CT							200						5				
Iron	M	5	CT							1,000						300 (5)				
Lead	M	100	CT			TVS				50						TVS				
Lithium	M	100	NC																	
Magnesium	M	5000	CT																	
Magnesium	M	15	CT							200						50 (5)				
Manganese	M	0.2	CT			2.4				0.1						0.01				
Mercury	M	200	NC																	
Molybdenum	M	40	CT																	
Nickel	M	5000	CT			TVS				200						TVS				
Potassium	M	5	CT																	
Selenium	M	10	CT			135				20						10				
Silver	M	5000	CT			TVS				50						TVS				
Sodium	M	200	NC																	
Strontium	M	10	CT																	
Thallium	M	200	NC																	
Tin	M	10	E6010																	
Titanium	M	10	E6010																	
Tungsten	M	50	CT																	
Vanadium	M	20	CT			TVS				2,000						TVS				
Zinc	M	5,000	CT							5,000										

TABLE 3.3
POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (10)	PQL MDL	Method (11)	Statewide Standards (a)										Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)					
				Tables A,B Carcinogens/ Noncarcinogens (2)	Table C Aquatic Life		Tables I,II,III (1)			Agricultural Standard (3)	Domestic Water Supply (6)	Organics (12) Aquatic Life	Water Supply	Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (8)		Table 2 Radionuclides		
					Acute Value (2)	Chronic Value (2)	Acute Value (2)	Chronic Value (2)	Acute Value (8)								Chronic Value (8)	Woman Creek	Walnut Creek		
2,4,5-TP Silvex	P		d	10										10							
2,4-D	P		d	100										100							
Aldicarb	P			10										10							
Aldrin	P	0.05	CP	0.002 (13)	3							0.003		0.002 (13)	0.000074			0.000074			
Bromacil	P		d	36										36							
Carbofuran	P																				
Chloranil	P		E619																		
Chlordane (Alpha)	P	0.5	CP	0.03 (13)	2.4	0.0043								0.03 (13)	0.00046			0.00046			
Chlordane (Gamma)	P	0.5	CP	0.03 (13)	2.4	0.0043								0.03 (13)	0.00046			0.00046			
Chlorpyrifos	P				0.083	0.041															
DDT	P	0.1	CP	0.1 (13)	1.1	0.001						0.001		0.1 (13)	0.000024			0.000024			
DDT Metabolite (DDD)	P	0.1	CP		0.6							0.001									
DDT Metabolite (DDE)	P	0.1	CP		1,050							0.1									
Demeton	P					0.1															
Diazinon	P																				
Dieldrin	P	0.1	CP	0.002 (13)	2.5	0.0019						0.003		0.002 (13)	0.000071			0.000071			
Endosulfan I	P	0.05	CP		0.22	0.056						0.003									
Endosulfan II	P	0.1	CP																		
Endosulfan Sulfate	P	0.1	CP																		
Endrin	P	0.1	CP	0.2	0.18	0.0023						0.004		0.2							
Endrin Ketone	P	0.1	CP																		
Guthion	P					0.01						0.01									
Heptachlor	P	0.05	CP			0.0038						0.001		0.008 (13)	0.00028			0.00028			
Heptachlor Epoxide	P	0.05	CP	0.008 (13)	0.52								0.2	0.004 (13)					0.0092		
Hexachlorocyclohexane, Alpha	P	0.05	CP												0.0092			0.0092	0.0163		
Hexachlorocyclohexane, Beta	P	0.05	CP												0.0163			0.0163			
Hexachlorocyclohexane, Delta	P	0.05	CP																		
Hexachlorocyclohexane, Tech.	P	0.05	f												0.0123			0.0123			

TABLE 3.3
POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Statewide Standards (a)															Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)				
Parameter	Type (10)	PQL MDL	Method (11)	Tables A,B Carcinogens/Noncarcinogens (2)		Table C Aquatic Life		Tables I,II,III (1)			Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radionuclide	Stream Segment Table (8)		Table 2 Radionuclides			
				Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (6)	Aquatic Life	Water Supply	Acute Value				Chronic Value	Woman Creek	Walnut Creek			
Hexachlorocyclohexane, Lindane	P	0.05	CP	4	2.0	0.08					0.01	4.0	4	0.0186			0.0186				
Malathion	P					0.1					0.1										
Methoxychlor	P	0.5	CP	100		0.03					0.03	100	100								
Mirex	P					620					0.001										
Parathion	P					0.013					0.04										
PCBs	P	0.5	CP	0.005 (13)	2.0	0.014					0.001		0.005 (13)	0.000079			0.000079				
Simazine	P		e																		
Toxaphene	P	1	CP	5	0.73	0.0002					0.005	5.0	5								
Vapontite 2	P																				
Aroclor 1016	PP	0.5	CP																		
Aroclor 1221	PP	0.5	CP																		
Aroclor 1232	PP	0.5	CP																		
Aroclor 1242	PP	0.5	CP																		
Aroclor 1248	PP	0.5	CP																		
Aroclor 1254	PP	1	CP											3			3				
Aroclor 1260	PP	1	CP																		
Atrazine	PP		e																		
Americium (pCi/l)	R																				
Americium 241 (pCi/l)	R	0.01																			
Cesium 134 (pCi/l)	R	1		80 (6)									80		30		0.05	0.05			
Cesium 137 (pCi/l)	R	1													80		80	80			
Gross Alpha (pCi/l)	R	1																			
Gross Alpha (pCi/l)	R	2																			
Gross Beta (pCi/l)	R	4																			
Gross Beta (pCi/l)	R																				
Plutonium (pCi/l)	R																				
Plutonium 238+239+240 (pCi/l)	R	0.01		15 (6)											15						
Radium 226+228 (pCi/l)	R	0.5/1.0 (14)		5 (6)											5						
Strontium 89+90 (pCi/l)	R	1																			
Strontium 90 (pCi/l)	R			8 (6)											8			8	8		

TABLE 3.3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Statewide Standards (a)										Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)						
Parameter	Type (10)	PQL MDL	Method (11)	Tables A,B Carcinogens/Noncarcinogens (2)	Table C Aquatic Life		Tables I,II,III (1)			Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radionuclide	Stream Segment Table (8)		Table 2 Radionuclides	
					Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (6)	Aquatic Life				Water Supply	Acute Value	Chronic Value	Woman Creek
Thorium 230-232 (pCi/l)	R			60 (6)										60				500
Tritium (pCi/l)	R			20,000 (6)										20,000				
Uranium 233+234 (pCi/l)	R																	
Uranium 235 (pCi/l)	R	0.6																
Uranium 238 (pCi/l)	R	0.6																
Uranium (Total) (pCi/l)	R													40				10
1,2,4,5-Tetrachlorobenzene	SV		b	2 (13)								2						
1,2,4-Trichlorobenzene	SV	10	CS															
1,2-Dichlorobenzene (Ortho)	SV	10	CS	620							620							
1,2-Diphenylhydrazine	SV		b	0.05 (13)								0.05 (13)						
1,3-Dichlorobenzene (Meta)	SV	10	CS	620							620							
1,4-Dichlorobenzene (Para)	SV	10	CS	75							75							
2,4,5-Trichlorophenol	SV	50	CS	700							700							
2,4,6-Trichlorophenol	SV	10	CS	2.0 (13)							2.0 (13)							
2,4-Dichlorophenol	SV	10	CS	21							21							
2,4-Dimethylphenol	SV	10	CS		2,020													
2,4-Dinitrophenol	SV	50	CS		2,120													
2,4-Dinitrotoluene	SV	10	CS										1.2					
2-Chloronaphthalene	SV	10	CS															
2-Chlorophenol	SV	10	CS		4,380													
2-Methylnaphthalene	SV	10	CS															
2-Methylphenol	SV	10	CS															
2-Nitroaniline	SV	50	CS															
2-Nitrophenol	SV	10	CS															
3,3-Dichlorobenzidine	SV	20	CS										0.01					
3-Nitroaniline	SV	50	CS															
4,6-Dinitro-2-methylphenol	SV	50	CS															
4-Bromophenyl Phenylether	SV	10	CS															

TABLE 3.3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

				Statewide Standards (a)										Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)					
Parameter	Type (10)	PQL MDL	Method (11)	Tables A,B Carcinogens/Noncarcinogens (2)	Table C Aquatic Life		Tables I,II,III (1)			Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radionuclide	Stream Segment Table (8)		Table 2 Radionuclides				
					Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (6)	Aquatic Life				Water Supply	Acute Value	Chronic Value	Woman Creek	Walnut Creek		
4-Chloroaniline	SV	10	CS																		
4-Chlorophenyl Phenyl Ether	SV	10	CS																		
4-Chloro-3-methylphenol	SV	10	CS		30																
4-Methylphenol	SV	10	CS																		
4-Nitroaniline	SV	50	CS																		
4-Nitrophenol	SV	50	CS																		
Acenaphthene	SV	10	CS			520															
Anthracene	SV	10	CS		1,700																
Benzidine	SV	10	d	0.0002 (13)	2,500						0.1	0.002 (13)	0.00012				0.000037				
Benzoic Acid	SV	50	CS																		
Benzo(a)anthracene	SV	10	CS																		
Benzo(e)pyrene	SV	10	CS																		
Benzo(b)fluoranthene	SV	10	CS																		
Benzo(g,h,i)perylene	SV	10	CS																		
Benzo(k)fluoranthene	SV	10	CS																		
Benzyl Alcohol	SV	10	CS																		
bis(2-Chloroethoxy)methane	SV	10	CS																		
bis(2-Chloroethyl)ether	SV	10	CS	0.03 (13)								0.03 (13)	0.0000037								
bis(2-Chloroisopropyl)ether	SV	10	CS																		
bis(2-Ethylhexyl)phthalate	SV	10	CS																		
Butadiene	SV																				
Butyl Benzylphthalate	SV	10	CS																		
Chlorinated Ethers	SV																				
Chlorinated Naphthalenes	SV																				
Chloroalkylethers	SV	10	CS								1.0						1.0				
Chlorophenol	SV																				
Chrysene	SV	10	CS																		
Dibenzofuran	SV	10	CS																		
Dibenz(a,h)anthracene	SV	10	CS																		

TABLE 3.3
POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (10)	PQL MDL	Method (11)	Statewide Standards (a)										Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)				
				Tables A, B Carcinogens/ Noncarcinogens (2)	Table C Aquatic Life		Tables I, II, III (1)			Domestic Water Supply (6)	Organics (12)	Tables A, B (2)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (8)		Table 2 Radionuclides			
					Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard Supply (3)						Acute Life	Water Supply	Acute Value	Chronic Value	Woman Creek	Walnut Creek
Dichlorobenzenes	SV	20	CS																	
Dichlorobenzidine	SV	10	CS																	
Diethylphthalate	SV	10	CS																	
Dimethylphthalate	SV	10	CS																	
Dinitrotoluene	SV	10	CS		330	230														
Di-n-butylphthalate	SV	10	CS																	
Di-n-octylphthalate	SV	10	CS																	
Ethylene Glycol	SV		d																	
Fluoranthene	SV	10	CS		3,980															
Fluorene	SV	10	CS																	
Formaldehyde	SV																			
Haloethers	SV																			
Hexachlorobenzene	SV	10	CS	0.02 (13)																
Hexachlorobutadiene	SV	10	CS	14	90	9.3														
Hexachlorocyclopentadiene	SV	10	CS	49	7	5.2														
Hexachloroethane	SV	10	CS		980	540														
Hydrazine	SV																			
Indeno(1,2,3-cd)pyrene	SV	10	CS																	
Isophorone	SV	10	CS	1,050	117,000															
Naphthalene	SV	10	CS		2,300	620														
Nitrobenzene	SV	10	CS	3.5 (13)	27,000															
Nitrophenols	SV																			
Nitrosamines	SV																			
Nitrosodibutylamine	SV		b																	
Nitrosodiethylamine	SV		b																	
Nitrosodimethylamine	SV		b																	
Nitrosopyrrolidine	SV		b																	
N-Nitrosodiphenylamine	SV	10	CSb																	
N-Nitroso-di-n-dipropylamine	SV	10	CSb																	

TABLE 3.3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

				Statewide Standards (a)										Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)					
Parameter	Type (10)	PQL MDL	Method (11)	Tables A, B Carcinogens/Noncarcinogens (2)		Table C Aquatic Life		Tables I, II, III (1)			Organics (12)		Tables A, B (2)	Table C Fish & Water Ingestion	Table D Radionuclide	Stream Segment Table (8)		Table 2 Radionuclides			
				Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (6)	Aquatic Life	Aquatic Life	Water Supply				Acute Value	Chronic Value	Woman Creek	Walnut Creek		
Pentachlorinated Ethanes	SV		b																		
Pentachlorobenzene	SV	50	b	9	5.7								6 (13) 200								
Pentachlorophenol	SV	10	CS																		
Phenanthrene	SV	10	CS	10,200	2,560																
Phenol	SV	10	CS																		
Phthalate Esters	SV		c																		
Polynuclear Aromatic Hydrocarbons	SV		b																		
Vinyl Chloride	SV	10	CV										2								
1,1,1-Trichloroethane	V	5	CV																		
1,1,2,2-Tetrachloroethane	V	5	CV		2,400																
1,1,2-Trichloroethane	V	5	CV		9,400																
1,1-Dichloroethane	V	5	CV																		
1,1-Dichloroethene	V	5	CV																		
1,2-Dichloroethane	V	5	CV	118,000	20,000																
1,2-Dichloroethene (cis)	V	5	a																		
1,2-Dichloroethene (total)	V	5	CV																		
1,2-Dichloroethene (trans)	V	5	CV																		
1,2-Dichloropropane	V	5	a	23,000	5,700																
1,3-Dichloropropene (cis)	V	5	CV	6,060	244																
1,3-Dichloropropene (trans)	V	5	CV	6,060	244																
2-Butanone	V	10	CV																		
2-Hexanone	V	10	CV																		
4-Methyl-2-pentanone	V	10	CV																		
Acetone	V	10	CV																		
Acrylonitrile	V		c	7,550	2,600																
Benzene	V	5	CV	5,300																	
Bromodichloromethane	V	5	CV											0.058							
Bromoform	V	5	CV										5								

TABLE 3.3
POTENTIAL CHEMICAL-SPECIFIC ARARS/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

				Statewide Standards (a)										Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)					
Parameter	Type (10)	PQL MDL	Method (11)	Tables A, B Carcinogens/Noncarcinogens (2)		Table C Aquatic Life		Tables I,II,III (1)			Organics (12)		Tables A, B (2)	Table C Fish & Water Ingestion	Table D Radionuclide	Stream Segment Table (8)		Table 2 Radionuclides			
				Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (6)	Aquatic Life	Water Supply	Acute Value				Chronic Value	Woman Creek	Walnut Creek			
Bromomethane	V	10	CV																		
Carbon Disulfide	V	5	CV																		
Carbon Tetrachloride	V	5	CV	5	35,200							5									
Chlorinated Benzenes	V	10	CV/CS																		
Chlorobenzene	V	5	CV/CS	300								300									
Chloroethane	V	10	CV																		
Chloroform	V	5	CV	Tot THM <100 (4)	28,900	1,240						Tot THM <100 (4)	0.19			0.19					
Chloromethane	V	10	CV																		
Dibromochloromethane	V	5	CV																		
Dichloroethenes	V	5	CV																		
Ethyl Benzene	V	5	CV	680	32,000							680									
Ethylene Dibromide	V		d																		
Ethylene Oxide	V																				
Halomethanes	V			100																	
Methylene Chloride	V	5	CV																		
Pyrene	V	10	CS																		
Styrene	V	5	CV																		
Tetrachloroethanes	V	5	CV																		
Tetrachloroethene	V	5	CV	10	5,280	840						10									
Toluene	V	5	CV	2,420	17,500							2,420									
Trichloroethanes	V	5	CV																		
Trichloroethene	V	5	CV	5	45,000	21,900						5									
Vinyl Acetate	V	10	CV																		
Vinylenes (Total)	V	5	CV																		

TABLE 3.3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (10)	PQL MDL	Method (11)	Statewide Standards (a)										Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)					
				Tables A,B Carcinogens/ Noncarcinogens (2)	Table C Aquatic Life		Tables I,II,III (1)			Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radio- nuclide	Stream Segment Table (8)		Table 2 Radionuclides				
					Acute Value (2)	Chronic Value (2)	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (6)	Acute Value				Chronic Value	Woman Creek	Walnut Creek				

EXPLANATION OF TABLE

- CLP = Contract Laboratory Program
 CDH = Colorado Department of Health
 dis = dissolved
 EPA = Environmental Protection Agency
 pCi/l = picocuries per liter
 PCB = polychlorinated biphenyl
 PQL = Practical Quantitation Level
 SS = species specific
 TAL = Target Analyte List
 THM = Total Trihalomethanes
 TIC = Tentatively Identified Compound
 TVS = Table Value Standard (hardness dependent), see Table III in (a)
 MDL = Minimum Detection Limit for radionuclides (pCi/l)
 ug/l = micrograms per liter
 VOA = Volatile Organic Analysis
 WQCC = Water Quality Control Commission

- (1) Table I = physical and biological parameters
 Table II = inorganic parameters
 Table III = metal parameters
 Values in Tables I, II, and III for recreational uses, cold water biota and domestic water supply are not included.
 (2) In the absence of specific, numeric standards for non-naturally occurring organics, the narrative standard is interpreted as zero with enforcement based on practical quantification levels (PQLs) as defined by CDH/WQCC or EPA
 (3) All are 30-day standards except for nitrate+nitrite
 (4) Total trihalomethanes: chloroform, bromoform, bromodichloromethane, dibromochloromethane
 (5) Lowest value given: dissolved or total recoverable

TABLE 3.3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (10)	PQL MDL (11)	Statewide Standards (a)										Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)							
			Tables A,B Carcinogens/ Noncarcinogens (2)		Table C Aquatic Life		Tables I,II,III (1)				Organics (12)		Tables A,B (2)		Table C: Fish & Water Ingestion		Table D Radio- nuclide		Stream Segment Table (8)		Table 2 Radionuclides	
Acute Value (2)	Chronic Value (2)	Acute Value (2)	Chronic Value (2)	Agricul- tural Standard (3)	Domestic Water Supply (6)	Aquatic Life	Water Supply															

(6) Ammonia, sulfide, chloride, sulfate, copper, iron, manganese, and zinc are 30-day standards, all others are 1-day standards

(7) Segment 5 standards are goals

(8) Includes Table 1: Additional Organic Chemical Standards (chronic only)

(9) See section 3.1.11 (f)(2) in (a)

(10) type abbreviations are: A=anion; B=bacteria; C=cation; D=dioxin; FP=field parameter; I=indicator; M=metal; P=pesticide; PP=pesticide/PCB; R=radionuclide; SV=semi-volatile; V=volatile

(11) method abbreviations are: CT=CLP-TAL; NC=non-CLP; CV=CLP-VOA; CS=CLP-SEMI; EP=EPA-PEST; CP=CLP-PEST; E=EPA; a = detected as total in CV; b = detected as TICs in CS; c = detected as TICs in CV;

d = not routinely monitored; e = monitored in discharge ponds; f = mixture-individual isomers detected.

(12) See Section 3.8.5 (2)(a) in (b)

(13) Standard is below (more stringent than) PQL, therefore PQL is standard.

(14) MDL for Radium 226 is 0.5; MDL for Radium 228 is 1.0

(a) CDH/WQCC, Colorado Water Quality Standards 3.1.0 (5 CCR 1002-8) 1/15/1974; amended 9/30/1989 (ARAR)

(Environmental Reporter 726:1001-1020:6/1990)

(b) CDH/WQCC, Classifications and Numeric Standards for S. Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin 3.8.0 (5 CCR 1002-8) 4/6/1981; amended 2/15/1990.

Basin-wide standards are ARAR; Site-specific standards are TBC.

4.0 DATA NEEDS AND DATA QUALITY OBJECTIVES

Phase I RFI/RI Data Quality Objectives (DQOs) have been developed for the collection of field data to supplement the existing, historical data which have been evaluated in Section 2.0 of this Work Plan. The field sampling and analysis program, which is detailed in Section 7.0 of this Work Plan, will strive to augment the available data by generating new information from untested areas within the site boundaries to achieve more uniform coverage of sampling. The program will also generate new types of information with consistent, standardized quality assurance objectives and procedures which increase validity, and establish relative levels of confidence for individual data and the resulting interpretations.

Portions of the historical data set for the Solar Ponds area are of uncertain quality, and apparent discrepancies prevent accurate, meaningful analysis. The proposed field sampling and analysis program will generate a comprehensive set of field observations, field measurements, and laboratory data types. The proposed use of each type of information will dictate the level of data quality required for that measurement.

Site-specific data requirements and related DQOs are summarized in Table 4-1. The data collection activities will focus on the characterization of the source and soils, as required of the Phase I RFI/RI by the IAG. Definition of contamination sources will include surface radiation surveys, vadose zone monitoring and testing of surficial and unconsolidated materials through field measurement, and laboratory analysis. Characterization activities will include geophysical investigations to delineate the Original Pond boundaries and subsurface features such as piping and tanks. The effectiveness of the ITS in capturing shallow ground water will also be evaluated. The program will include installing upgradient wells to expand the RCRA monitoring network.

The primary objective of an RFI/RI is collection of data necessary to evaluate the nature, distribution, and migration pathways of contaminants and to quantify any risks to human health and the environment. These assessments determine the need for remediation and are used to evaluate remedial alternatives, if necessary. The five general goals of an RFI/RI (U.S. EPA, 1988a) are as follows:

1. Characterize site physical features
2. Define contaminant sources
3. Determine the nature and extent of contamination

4. Describe contaminant fate and transport
5. Provide a baseline risk assessment

However, in accordance with the IAG, the RFI/RI for OU4 has been divided into two phases. Phase I of the RFI/RI will address characterization of the site physical features and definition of contaminant sources. Phase II of the RFI/RI will address determination of the nature and extent of contamination and evaluation of the fate and transport of contaminants at OU4.

Data quality objectives (DQOs) are qualitative and quantitative statements that specify the quality and quantity of data required to support the objectives of the RFI/RI (U.S. EPA, 1987). The DQO process is divided into three stages:

- Stage 1 - Identify decision types
- Stage 2 - Identify data uses/needs
- Stage 3 - Design data collection program

Through application of the DQO process, site-specific goals were established for the Phase I RFI/RI and data needs were identified for achieving those goals. This section of the RFI/RI Work Plan proceeds through the DQO process specific to the Phase I RFI/RI for OU4.

Data collected during previous investigations have been useful in developing and focusing the DQOs. Previous data collection activities focused on site characterization rather than performing a quantitative risk assessment or environmental evaluation. The historical data, along with the OU4 conceptual model, were summarized in Section 2.0 of this Work Plan. This section presents the rationale used in identifying OU4 data needs.

4.1 STAGE 1 - IDENTIFY DECISION TYPES

Stage 1 of the DQO process identifies decision makers, data users, and the types of decisions that will be made as part of the Phase I RFI/RI. The general decision types were identified early in Stage 1 to determine data types sufficient to support decisions.

4.1.1 Identify and Involve Data Users

Data users are divided into three groups: decision makers, primary data users, and secondary data users. The decision makers for OU4 are personnel from EG&G, DOE, EPA, and CDH who are responsible for decisions related to management, regulation, investigation, and remediation of OU4.

The decision makers are involved through the review and approval process specified in the IAG. Primary data users are individuals involved in ongoing Phase I RFI/RI activities for OU4. These individuals are the technical staff of CDH, EPA, EG&G, and EG&G subcontractors, including geoscientists, statisticians, risk assessors, engineers, and health and safety personnel. They will be involved in collection and analysis of data and in preparation of the Phase I RFI/RI report, including the Baseline Human Health Risk Assessment and the Environmental Evaluation. Secondary data users are those users who rely on RFI/RI outputs to support their activities. Secondary data users of the Phase I RFI/RI information may include personnel from EPA, CDH, EG&G, and EG&G subcontractors working in areas such as data base management, quality assurance, records control, and laboratory management.

4.1.2 Evaluate Available Data

The historical and recently conducted investigations at the Solar Ponds and associated areas of OU4 have generated a significant quantity of data that is described in Section 2.0 of this Work Plan. The following is a brief discussion of the completeness and usability of existing data based on the information presented in Section 2.0.

4.1.2.1 Quality and Usability of Analytical Data

Analytical data used in characterizing contamination at OU4 are in the process of being validated in accordance with EM Program QA procedures. As of early 1991, only a small fraction of the data has been validated. At present much of the analytical data for radionuclides have been rejected. Data were rejected because (1) sampling/analytical protocol did not conform to significant aspects of the QA/QC Plan (Rockwell International, 1989a) or (2) there is insufficient documentation to demonstrate conformance with these procedures. These data, at best, can be considered only qualitative measures of the analyte concentrations. Analytical data generated during the 1991 sampling and analysis of Solar Pond liquids and sludges is of significantly better quality than previous Solar Pond data (Weston, 1991).

The analytical data have been used qualitatively to scope the Phase I RFI/RI activities at OU4 as presented in this Work Plan. Valid data are needed to accurately evaluate contamination at OU4. Additionally, data obtained periodically are needed to perform statistical evaluations of ground water quality and to assess temporal trends.

Presently, under the site-wide RCRA ground water monitoring program, ground water quality at OU4 is compared to sitewide definitions of background ground water quality to evaluate contamination. The methods used to establish background chemical quality at the RFP are presented in the Final Background Geochemical Characterization Report for 1989, Rocky Flats Plant (EG&G, 1990d). In accordance with RCRA guidance, ground water quality immediately upgradient of the site must be evaluated to accurately assess potential contamination related to the Solar Ponds and to differentiate contamination from other potential sources located upgradient of the site (U.S. EPA, 1988a). Therefore, the installation of upgradient/background ground water monitoring wells has been included in this Phase I RFI/RI Work Plan.

4.1.2.2 Physical Setting

The physical setting of the Solar Ponds area is described in detail in Section 2.0. Additional data are needed for consistency and to provide more thorough coverage of the site.

4.1.2.3 Characterization of Contamination of the Solar Ponds

The nature of contamination is described in detail in Section 2.5. Weston has thoroughly characterized the pond liquids and sludges and no further data are needed. However, additional data for the soils are needed to fully characterize the site.

4.1.3 Develop Conceptual Model

A conceptual model for OU4 has been developed in Section 2.6 and is illustrated in Figure 2-30. This model includes a description of contaminant sources, release mechanisms, transport medium, contaminant migration pathways, exposure routes, and receptors. Because few previous studies have provided valid data, the model is a basic Phase I model. The site-specific conceptual model for OU4 is discussed briefly below.

The primary source of contamination at the Solar Ponds are the liquids and sludges contained in the ponds. Secondary sources of contamination may include lining materials and base course materials; soils beneath the Solar Ponds that have been contaminated by pond liner and/or pipeline leakage; ground water, contaminated surface water, and contaminated surface soils as a result of aerosol dispersion from the ponds.

The primary release mechanisms for contaminants from the Solar Ponds are likely to be pond liner leakage, pipeline leakage and windblown aerosols. The exposure pathways for contaminants from

the Solar Ponds to reach receptors are via ingestion, inhalation, or dermal contact to windblown contaminated soil, contaminated ground water, and surface water. Receptors are defined as the human or ecological populations exposed to contaminants at the exposure points. Human receptors include primarily present and future RFP workers and secondarily residents living downwind and/or downgradient of OU4. Ecological receptors include terrestrial wildlife, aquatic wildlife, and terrestrial and aquatic vegetation in and around OU4.

4.1.4 Specify Phase I RFI/RI Objectives and Data Needs

Based on the existing site information (Sections 2.2 through 2.4), the nature of contamination (Section 2.5), the site-specific conceptual model for OU4 (Section 2.6), and an evaluation of the quality and usability of the existing data (Section 4.1.2), site-specific Phase I RFI/RI objectives/data needs associated with identifying contaminant sources and characterizing contamination have been developed. These are summarized in Table 4.1 and are discussed below.

In accordance with the IAG, the specific objectives of the Phase I RFI/RI field investigation for OU4 are as follows:

Characterize Site Physical Features and Define Contaminant Sources

- Determine the boundaries of the Original Pond.
- Assess the Interceptor Trench System
 - Determine the extent at which the ITS is keyed into bedrock
 - Determine the head differential across the ITS
- Delineate sandstone paleochannels/fracture sets in bedrock
- Install upgradient/background ground water monitoring wells for IHSS 101 (the Solar Ponds)
- Investigate presence of subsurface piping
- Determine the presence or absence of contamination in surficial soils
- Determine the presence or absence of contamination in subsurface/vadose zone materials.

As previously discussed in Sections 2.3 and 2.5, extensive analysis of pond liquids and sludges have already been conducted in order to characterize the chemical, radiochemical and geochemical characteristics of the material contained in each pond. Historical results and the May 1991 sampling

and analysis by R. F. Weston are deemed sufficient to characterize the Solar Ponds' liquids and sludges. Therefore, further sampling and analysis is not proposed.

Provide a Baseline Risk Assessment

The objectives of the Baseline Risk Assessment are discussed in Sections 8.0 and 9.0.

Determine Nature and Extent of Contamination

This will be addressed in the Phase II RFI/RI Work Plan.

Describe Contaminant Fate and Transport

This will be addressed during Phase II RFI/RI Work Plan.

4.2 STAGE 2 - IDENTIFY DATA USES/NEEDS

The data needed to meet each of the site-specific Phase I RFI/RI objectives developed for OU4 are listed in Table 4-1. The associated sampling and analysis activities are also identified in Table 4-1. Specific plans for obtaining the needed data are presented in Section 7.0 (Field Sampling Plan). The following sections discuss the uses, general types, quality, and quantity of the data needed for the OU4 Phase I RFI/RI.

4.2.1 Identify Data Uses

RFI/CMS data can be categorized according to use for the following general purposes:

- Site characterization
- Health and safety
- Risk assessment
- Evaluation of alternatives
- Engineering design of alternatives
- Monitoring during remedial action
- Determination of potentially responsible parties (PRPs)

Because this Work Plan describes a Phase I RFI/RI, data uses such as engineering design and monitoring during remediation (both remedial action activities) will not be considered. The data use for PRP determination is also not appropriate to this Work Plan. The remaining four data uses will be important in meeting the objectives identified in Section 4.1.4. Data uses for specific sampling and analysis activities for the Phase I investigation at OU4 are listed in Table 4-1.

4.2.2 Identify Data Types

Data types can be initially divided into broad groups and again divided into more specific components. Examples of data types include geophysical data, physical data, chemical data, water level data, and field screening data.

For the Phase I investigation, surficial soil, and subsurface unconsolidated material and ground water samples will be collected. Radiation surveys will be conducted over the Solar Ponds area and geophysical surveys will be conducted in the areas of the Original Pond, the Solar Ponds and the ITS. Vadose zone monitoring and water level determination at the ITS will also be conducted. These data types will provide Phase I information to further characterize physical features and contamination at OU4. Selection of chemical analyses has been based on the objectives of the Phase I program and on the past activities at the units. Data types are listed in Table 4-1.

4.2.3 Identify Data Quality Needs

EPA defines five levels of analytical data, listed as follows (U.S. EPA, 1987):

- Level I - Field screening or analysis using portable instruments. Results are often not compound-specific and not quantitative, but results are available in real time. It is the least costly of the analytical options.
- Level II - Field analysis using more sophisticated portable analytical instruments; in some cases, the instruments may be set up in a portable laboratory onsite. There is a wide range in the quality of the data that can be generated. The quality depends on the use of suitable calibration standards, reference materials, and sample preparation equipment and on the training of the operator. Results are available in real time or several hours.
- Level III - All analysis performed in an offsite laboratory. Level III analyses may or may not be performed according to CLP procedures, but the validation or documentation procedures required of CLP Level IV analysis are not usually utilized. The laboratory may or may not be a CLP laboratory.
- Level IV - CLP routine analytical services (RAS). All analyses are performed in an offsite CLP analytical laboratory following CLP protocols. Level IV is characterized by rigorous QA/QC protocols and documentation.
- Level V - Analysis by non-standard methods. All analyses are performed in an offsite analytical laboratory that may or may not be a CLP laboratory. Method development or method modification may be required for specific constituents or detection limits. CLP special analytical services (SAS) are Level V.

All five levels of data quality will be necessary for performing Phase I field activities. The levels appropriate to the data need and data use have been specified in Table 4-1.

Data quality for the Phase I RFI/RI will be achieved by meeting the requirements for Level I through V data outlined in GRRASP (EG&G, 1991j) and by adhering to the data collection protocols provided in agency-approved Standard Operating Procedures (SOPs) and Procedure Change Notices (PCNs).

4.2.4 Identify Data Quantity Needs

Data quantity needs are based primarily on an evaluation of the information available for characterizing the site physical features and contamination at OU4. This is consistent with guidance provided in Data Quality Objectives for Remedial Response Activities (U.S. EPA, 1987) and Guidance for Data Useability in Risk Assessments (U.S. EPA, 1990). Additionally, data quantity needs are designed to be consistent with similar data collection activities performed for the Phase I RFI/RI for OU 6 (Walnut Creek) and OU 9 (Original Process Waste Lines). The rationale for sampling quantities is described in the FSP presented in Section 7.0 of this Work Plan.

To ensure that a sufficient amount of valid data are generated, the FSP was designed to include (1) a rationale for all field activities based on an evaluation of the existing information, (2) a phased approach using screening-level techniques to identify and/or locate critical sampling sites, and (3) contingency plans for obtaining data from critical locations. These components of the FSP are discussed further in Section 7.0.

4.2.5 Evaluate Sampling/Analysis Options

To ensure that sufficient and adequate data are collected, the Phase I RFI/RI for OU4 is based on a stepped, or phased, approach in which field screening techniques (e.g., Level I and II data types) are used to direct data collection activities designed to obtain Level III through V data. This stepped program has been designed to be consistent with the IAG schedule.

This approach maximizes collection of useful data because field screening techniques are used to properly locate and minimize intrusive data collection activities such as borehole drilling. Additionally, this approach minimizes the volume of hazardous waste material generated that requires special management, the potential exposure of field personnel to hazardous waste material, and the overall time to perform the field activities.

Three types of activities will be performed during the Phase I field investigation: (1) screening activities, (2) sampling activities, and (3) monitoring well installation. Screening activities (Levels I

and II) include visual inspection, radiological surveys, and geophysical techniques. Analysis of surficial soils and subsurface materials from test borings, will provide Level III through IV data. Monitoring wells will provide Level I type data.

Sampling options for the Phase I RFI/RI were selected on the basis of their ability to (1) obtain data consistent with the DQOs in the least intrusive manner, (2) obtain multiple types of data at each sampling location, and (3) reduce the number of "leave-behind" sampling locations requiring long-term maintenance and care.

4.2.6 Review of PARCC Parameter Information

PARCC parameters are indicators of data quality. Precision, accuracy, and completeness goals are established for this Work Plan according to the analyses being performed and the analytical levels. PARCC goals are specified in the Quality Assurance Addendum (QAA) discussed in Section 10.0 of this Work Plan.

The analytical program requirements for OU4 are discussed in Section 7.4 of this Work Plan. The GRRASP (EG&G, 1991j) and the RFP site-wide Quality Assurance Project Plan (QAPjP) provide listings of the CLP analytes and detection/quantification limits for Target Compound List (TCL) volatile organics, semivolatile organics, pesticides/PCBs, Target Analyte List (TAL) metals, radionuclides, and inorganic parameters. These analytical methods are appropriate for meeting the data quality requirements for analytical Levels I through V during the Phase I RFI/RI. The precision, accuracy, and completeness parameters for analytical Levels I through V are discussed below, along with the completeness and representativeness for all analytical levels.

Precision measures the reproducibility of measurements under a given set of conditions. Accuracy measures the bias or source of error in a group of measurements. Precision and accuracy objectives for the analytical data collected for the Phase I RFI/RI at OU4 will be evaluated according to the control limits specified in the referenced analytical method and/or in data validation guidelines. For the radionuclide analyses, the accuracy objectives specified in the GRRASP the RFP site-wide QAPjP will be followed. The specified criteria for precision and accuracy are described in the QAA. Precision and accuracy for non-analytical data will be achieved through protocols outlined in agency-approved SOPs and PCNs.

Completeness is defined as the percentage of measurements made that are judged to be valid. The target completeness objective for the OU4 field and analytical data is 100 percent, although 90 percent will be the minimum acceptable level. The FSP was designed to generate a sufficient amount of valid data and to include (1) a rationale for all field activities based on an evaluation of the existing information, and (2) a phased approach using screening level techniques to identify and/or locate critical sampling sites. These components of the FSP are discussed further in Section 7.0.

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. In order to achieve comparability, work will be performed at OU4 in accordance with approved sampling and analysis plans, standard analytical protocols, and approved SOPs for data collection. Consistent units of measurement will be used for data reporting.

Representativeness expresses the degree to which sample data accurately and precisely represent the characteristics of a particular site or condition. Representativeness is a qualitative parameter related to the design of the sampling and analysis components of the investigative program. The FSP described in Section 7.0 of this Work Plan and the referenced SOPs describe the rationale for the sampling program to provide for representative samples.

4.3 STAGE 3 - DESIGN DATA COLLECTION PROGRAM

The purpose of Stage 3 of the DQO process is to design the specific data collection program for the Phase I RFI/RI for OU4. To accomplish this, the elements identified in Stages 1 and 2 are assembled and the Sampling and Analysis Plan (SAP) prepared. The SAP consists of (1) a Quality Assurance Project Plan (QAPjP) that describes the policy, organization, functional activities, and QA/QC protocols necessary to achieve the DQOs dictated by the intended use of the data and (2) a FSP that provides guidance for all fieldwork by defining in detail the sampling and data collection methods to be used in the Phase I RFI/RI for OU4. These two components are presented in Sections 7.0 and 10.0 of this Work Plan. A detailed discussion of all samples to be obtained is presented in Section 7.0 for each media and includes sample type, number of samples, sample location, analytical methods, and QA/QC samples.

TABLE 4.1
PHASE I RFI/RI DATA QUALITY OBJECTIVES FOR OU4

Objective (Data Need)	Data Type	Sampling/Analysis Activity	Analytical Level	Data Use
1) Determine the boundaries of the Original Pond.	Facility drawings, aerial photographs, construction reports Geophysical data Chemical/physical data of soil/fill	Review facility engineering drawings, aerial photos, and reports.	NA	Site characterization Evaluation of remedial alternatives Baseline risk assessment Environmental evaluation
		Conduct GPR survey in vicinity of original pond.	I	
		Process and analyze data.		
		Conduct follow-up GPR survey as needed.		
		Collect soil/fill core samples along depth profiles, analyze for full-suite.	IV (V for radiological analyses)	
2) Assess the Interceptor Trench System (ITS). a) Determine the extent at which the ITS is keyed into bedrock. b) Determine the head differential across the ITS.	Facility Drawings, As-Built Drawings Water level data	Review facility engineering drawings and reports.	NA	Site characterization Evaluation of remedial alternatives
		Install piezometers across the ITS and obtain monthly water level measurements.	I	
3) Delineate sandstone paleochannel	Physical data of bedrock	Review existing geologic data.	N/A	Site characterization
		Collect soil core samples and analyze/log cores.	I	
4) Delineate fracture sets in bedrock	Physical data of bedrock integrity	Collect soil core samples and analyze/log cores.	I	Site characterization

TABLE 4.1
PHASE I RF/RI DATA QUALITY OBJECTIVES FOR OU4
(Continued)

Objective (Data Need)	Data Type	Sampling/Analysis Activity	Analytical Level	Data Use
5) Install upgradient/background groundwater monitoring wells for IHSS 101.	Water level data Chemical data	Drill and install monitoring wells for incorporation with other programs.	I	Site characterization Baseline risk assessment
		One-time baseline sampling of ground water, analyze for full-suite. (Thereafter, other programs will obtain water level and chemical data on a routine basis.)	IV (V for radiological analyses)	Environmental evaluation Evaluation of remedial alternatives
6) Investigate presence of subsurface piping	Geophysical Data OPWL records	Conduct GPR survey in vicinity of Original Pond and Existing Ponds	I	Site characterization
		Process and analyze data	I	
		Conduct follow-up GPR as needed	I	
7) Determine the presence or absence of contamination in surface soils.	Radiological data Chemical data Physical data	Conduct radiological survey.	II	Site characterization Baseline risk assessment
		Collect surficial soil scrapes; analyze for selected parameters	IV (V for radiological analyses)	Environmental evaluation Evaluation of remedial alternatives

TABLE 4.1
PHASE I RFI/RI DATA QUALITY OBJECTIVES FOR OU4
(Continued)

Objective (Data Need)	Data Type	Sampling/Analysis Activity	Analytical Level	Data Use
8) Determine the presence or absence of contamination in subsurface/unconsolidated materials.	Radiological data Chemical data Physical data	Collect soil samples along depth profiles, analyze for selected parameters dependent on location of borehole.	IV (V for radiological analyses)	Site characterization Baseline risk assessment Environmental evaluation Evaluation of remedial alternatives
9) Determine the presence or absence of contamination in vadose zone materials	Vadose zone monitoring data (lysimeters, tensiometers, soil vapor detectors)	Install vadose zone monitoring equipment	I	Site characterization

5.0 RCRA FACILITY INVESTIGATION/REMEDIAL INVESTIGATION TASKS

5.1 TASK 1 - PROJECT PLANNING

Project planning for the implementation of the Phase I RFI/RI for OU4 will include numerous activities in addition to tasks completed as part of this Work Plan. Review of previous site investigations, preliminary site characterization, preliminary identification of potential ARARs and the development of Data Quality Objectives and a FSP have all been completed as part of this Work Plan and are contained in Sections 2.0, 3.0, 4.0, and 7.0.

Prior to performing field activities for OU4, it will be necessary to review new information and data that become available after preparation of this Work Plan. Additional planning will be required to; 1) coordinate with other field investigation programs occurring in the same vicinity and ongoing operations at the Solar Ponds (i.e., pond dewatering and sludge removal), 2) accommodate the special requirements of security within the Protected Area (PA) and 3) evaluate and plan for health and safety concerns.

The schedule and completion of field activities will be contingent on the clean out of the individual ponds. The schedule as to when individual ponds will be cleaned and available for field investigative activities is uncertain. Therefore, flexibility has been incorporated into the Field Sampling Plan (Section 7.0). Other nearby OU field programs such as OU6, Walnut Creek Drainage, and of particular note, OU9, Original Process Waste Lines (OPWL) will be generating analytical and site characterization data.

The OPWL network resides extensively within the boundaries of the Solar Ponds area and represent significant potential sources of contamination which will be investigated as a separate OU. However, planning of these activities should be closely coordinated with OU4 activities to prevent redundancy and to optimize efficiency.

Security requirements of working within the PA will require detailed planning and coordinating with RFP personnel. The use of pickup trucks and other vehicles will likely be constrained. It is anticipated that health and safety requirements, such as level of personnel protective equipment, will be dependent on the areas within OU4 and other ongoing activities. Daily coordination and scheduling with ongoing activities will need to be conducted to ensure proper health and safety measures.

5.2 TASK 2 - COMMUNITY RELATIONS

In accordance with the IAG, the RFP is developing a Community Relations Plan (CRP) to inform and actively involve the public in decision-making as it relates to environmental restoration activities. The vehicle for public involvement in the RFI/RI process is through the Technical Review Group process. The CRP will address the needs and concerns of the surrounding communities as identified through approximately 80 interviews with federal, state, and local elected officials; businesses; medical professionals; educational representatives; interest groups; media; and residents adjacent to the RFP.

A Draft CRP was issued for public comments in January 1991. The Draft CRP was revised to reflect public comment, and following EPA and CDH approval, a final CRP was scheduled to be released in August 1991. Accordingly, a site-specific CRP is not required for OU4.

Current community relations activities concerning environmental restoration include participation by plant representatives in informational workshops; presentations at meetings of the Rocky Flats Environmental Monitoring Council; briefings for citizens, businesses, and surrounding communities on environmental restoration and monitoring activities; and public comment opportunities on various EM Program plans and actions. RFP personnel involve several special interest groups in decisions that pertain to environmental restoration activities, including the Rocky Flats Cleanup Commission, the recipient of the EPA Technical Assistant Grant.

In addition, a Speakers' Bureau program provides plant speakers to civic groups and educational organizations, and a public tours program allows the public to visit the RFP. The RFP also produces fact sheets and periodic updates on environmental restoration activities for public information and responds to numerous public inquiries regarding the RFP.

5.3 TASK 3 - FIELD INVESTIGATION

The Phase I RFI/RI field investigation for the Solar Ponds area is designed to meet the objectives outlined in Section 4.0 of this Work Plan. Additionally, the data will be used to support the Phase I Environmental Evaluation and the Phase I Human Health Risk Assessment.

Several types of activities will be performed during the Phase I field investigation including screening activities, sampling activities, and monitoring well installation. Screening activities include radiological surveys, geophysical investigations, visual inspections, and piezometer

installation. Technical details regarding these activities are discussed in Section 7.0. Sampling activities include surficial soil sampling, subsurface sampling using vadose zone borings, and ground water sampling. Two monitoring well clusters will be installed at upgradient locations and will be sampled after completion and development. The activities described below will be performed as part of the field investigation, as described in detail in Section 7.0.

5.3.1 Upgradient Ground Water Monitor Well Installation

- New ground water data will be reviewed to verify that proposed cluster well locations are upgradient of OU4.
- Monitor well clusters will be installed.
- One ground water sample will be collected from each well and analyzed for the full list of parameters analyzed in the RCRA Monitoring Program.

5.3.2 Site-Wide Radiological Survey and Surficial Sampling Program

- Alpha and gamma/beta radiation readings will be taken at nearly 350 locations throughout the Solar Ponds area. Real-time radiation readings will be used to assess surficial radiation in the Solar Ponds area, transported by aerosol dispersion or as seeps to the surface. Readings will be taken at each node of a 100-foot by 100-foot grid in the ITS area, and at nodes of a more dense grid in the Solar Ponds area.
- A one-inch composite surficial soil sample will be collected at randomly selected locations within the grid system described above. Samples will be collected at a ratio of 1 in 10 survey points (approximately 35 samples) and analyzed for metals, inorganics and radionuclides.

5.3.3 Vadose Zone Monitoring

- Research on available vadose zone monitoring techniques will be conducted and their applicability to the Solar Ponds area assessed.
- Instrumentation such as lysimeters, tensiometers or other techniques will be utilized for potential use at the Solar Ponds area.

5.3.4 Original Pond Investigation

- Available documentation regarding the Original Pond will be obtained and reviewed possibly including original construction drawings, aerial photographs before, during, and after 1952 to 1970, and any other available historical documentation.

- The surface radiation survey and surficial soil sampling program described in Section 5.3.2 above includes the Original Pond area.
- A surface geophysical investigation using ground penetrating radar (GPR) will be performed to delineate boundary of Original Pond and to locate subsurface features such as piping and tanks. The results will be coordinated with the OPWL investigation.
- Borehole construction and soil sample analysis will be conducted at four locations in the Original Pond area. Three boreholes will be placed within the perimeter of the old pond, and one will be placed on the perimeter of the Original Pond.
- A 0 to 1-inch sample will be collected at each borehole to provide data comparable to the surficial soil program. A minimum of five-foot intervals will be collected thereafter. Downhole geophysical investigations will be conducted at each borehole. Samples will be analyzed for metals, inorganics, radionuclides, volatile and semivolatile organic compounds, pesticides, and nitrate.

5.3.5 Solar Ponds Area

- Any recently obtained data in the vicinity of the Solar Ponds will be reviewed such as monthly surface water monitoring results and quarterly ground water monitoring results. Any additional data generated as a result of pond liquid and sludge removal operations will also be obtained and reviewed.
- Surface radiation survey and surficial soil sampling program described in Section 5.3.2 includes the Solar Ponds area.
- A surface geophysical investigation using GPR will be performed to identify subsurface features such as piping or tanks. The results will be coordinated with the OPWL investigation.
- A visual survey of pond liner damage will be conducted and locations of liner cracks or damage placed on a map.
- Borehole construction and soil sample analysis will be conducted at 17 locations inside the ponds, and 10 locations on or near pond embankments. Borings inside the ponds will be placed in cracks identified in the visual survey and in areas where the liner is in good condition to determine if the cracks provided the primary pathways for contaminant migration. The liner and base course will be removed at the borehole, and undisturbed materials below sampled. A 0 to 1-inch sample and 5-foot minimum samples thereafter will be collected. Perimeter boreholes are intended to assess lateral migration of pond contaminants, and will be sampled at the same intervals as borings inside the ponds. Proposed analyses include those listed for the Original Pond soil samples.

5.3.6 Interceptor Trench System and Remainder of Site

- Available documentation will be reviewed and personnel interviews conducted regarding the ITS design and construction.

- The surface radiation survey and surficial soil sampling program described in Section 5.3.2 includes the ITS and remainder of site.
- Boreholes will be constructed in the ITS, downgradient of the ITS and on the outer edges of the Solar Ponds area to investigate vadose zone contaminants. Sampling intervals are consistent with those described above. The analytical parameter list includes metals, nitrate, inorganics, and radionuclides.
- A series of piezometers will be installed in three locations across the primary french drain and in two finger drains to provide hydrologic characterization information. Water levels will be obtained and used to assess system effectiveness. Once installed and preliminary effectiveness evaluated, tracer studies may be proposed to investigate potential contaminated flow paths.

5.4 TASK 4 - SAMPLE ANALYSIS AND DATA VALIDATION

Analytical procedures will be completed in accordance with the ER Program QAPjP (EG&G, 1991k). Analytical detection limits, sample container and volume requirements, preservation requirements, and sample holding times are discussed in Section 7.4 of the FSP.

Results of data review and validation activities will be documented in data validation reports. EPA data validation functional guidelines will be used for validating organic and inorganic (metals) data (U.S. EPA, 1988c). Data validation methods for radiochemistry and major ions data have not been published by EPA, but data and documentation requirements have been developed by EM Program QA staff. Data validation methods for these data are derived from these requirements. Details of the data validation process are described in the QAPjP (EG&G, 1991k).

Phase I data will be reviewed and validated according to data validation guidelines in the QAPjP and the Data Validation Functional Guidelines (EG&G, 1990b). These documents state that the results of data review and validation activities will be documented in data validation reports.

5.5 TASK 5 - DATA EVALUATION

Data collected during the Phase I RFI/RI, as well as previously collected data, will be incorporated into the existing RFEDS database and will be used to better characterize contaminant sources and soil. These results also will be used in delineating the requirements for the Phase II RFI/RI plans for determining the impact of OU4 on surface water, ground water, air, the environment, and biota, as well as the potential contaminant migration pathways at OU4. Additionally, data will be used to support the evaluation of proposed remedial alternatives and the BRA.

5.5.1 Site Characterization

The additional data collected during Phase I will be incorporated into the existing site characterization. Geophysical data will be used in the delineation of the Original Pond. Physical and chemical data will be used in the delineation of the Original Pond and to delineate sandstone channels and possible fracturing in the bedrock. The site geologic map and cross sections will be revised on the basis of new information. Water level data will be used to characterize the ground water flow regime in the vicinity of the Solar Ponds and to assess the effectiveness of the ITS.

5.5.2 Source and Soils Characterization

Analytical data from unconsolidated material samples and surficial soils will be used to:

- Characterize the nature of source contaminants
- Characterize the lateral and vertical extent of source contaminants
- Evaluate on-site contaminant concentrations
- Quantify the volume of source material.

Analytical data obtained from samples of soils will be used to characterize the sources of contamination. Data will be summarized graphically and/or in tabular form to assist interpretation. If appropriate, contaminant isopleth maps will be prepared to summarize the spatial distribution of source and soil contaminants.

The criteria for the identification of contamination will be analyte-specific for each geologic unit (such as the Rocky Flats Alluvium, Colluvium, or artificial fill). For all analytes (including radionuclides), only those concentrations that exceed the site-specific background concentrations will be considered likely evidence of contamination. These data will be compared to sitewide background values provided in the Final Background Geochemical Characterization Report for 1989 (EG&G, 1990d).

5.6 TASK 6 - PHASE I BASELINE RISK ASSESSMENT

As required by the IAG, a Baseline Risk Assessment (BRA) that will address the risk associated with source and soils will be performed as part of the Phase I RFI/RI report. The BRA includes a Human Health Risk Assessment and an Environmental Evaluation for OU4. The purpose of the Human Health Risk Assessment and Environmental Evaluation are to assess the potential human health and environmental risks associated with the site and to provide a basis for determining whether remedial actions are necessary. In accordance with the IAG, risks will be calculated at the

source. The Human Health Risk Assessment will address potential public health risks, and the Environmental Evaluation will address environmental impacts.

Existing data and data collected during the Phase I RFI/RI will be used to support the quantitative Human Health Risk Assessment and Environmental Evaluation. The sampling program will be designed to generate data that meet the requirements set forth in Guidance For Data Useability In Risk Assessment (U.S. EPA, 1990).

These assessments will aid in the preliminary screening of site remedies based on the contaminants of concern and the environmental media associated with potential risks to public health and the environment. The risk assessment process will be accomplished in five general steps:

1. Identification of chemicals of concern
2. Exposure assessment
3. Toxicity assessment
4. Risk characterization
5. Qualitative and quantitative uncertainty analysis.

As stated in the IAG, a risk characterization of the following scenarios will be developed:

1. Current site conditions (No Action Alternative)
2. Worker and public exposure during remedial action
3. Past remedy risk.

If the Human Health Risk Assessment and Environmental Evaluation determine that risks posed by contamination at OU4 must be remediated, Tasks 7 and 8 will be conducted.

The objectives and the description of work for the Human Health Risk Assessment are described in detail in Section 8.0 of this Work Plan. The Environmental Evaluation Work Plan is presented in Section 9.0.

5.7 TASK 7 - DEVELOPMENT, SCREENING, AND DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

5.7.1 Remedial Alternatives Development and Screening

This section identifies potential technologies applicable to remediation of contaminated soils, surface water, and ground water within and affected by OU4. The identified technologies are based on the preliminary site characterization developed in Section 2.0. Identification and screening of technolo-

gies, assembling an initial screening of alternatives, and identification of interim response actions will be conducted while the Phase I RFI/RI is being conducted. However, investigation of this operable unit is in its early stages; thus, remedial alternatives are only briefly reviewed in this section. A more detailed evaluation of the remedial alternatives for OU4 will be performed as more data are collected.

The process employed to develop and evaluate alternatives for OU4 will follow guidelines provided in the National Contingency Plan (NCP). Although RCRA regulations will direct remedial investigations at OU4, the CERCLA process will also be considered for guidance because it specifies in greatest detail the steps that should be followed for selection of remedial alternatives. In addition, the IAG requires general compliance with both RCRA and CERCLA guidance.

The steps followed to develop remedial alternatives for OU4 are as follows:

1. Develop a list of general types of actions appropriate for OU4 (such as containment, treatment, and/or removal) that may be implemented to satisfy the objectives defined in the previous step. These general types or classes of actions are generally referred to as "general response actions" in EPA guidance.
2. Identify and screen technology groups for each general response action. Screening will eliminate groups that are not technically feasible at the site.
3. Identify and evaluate process options for each technology group to select a process option representing each technology group under consideration. Although specific process options are selected to represent a technology group for alternative development and evaluation, these processes are intended to represent the broader range of options within a general technology group.
4. Assemble the selected representative technologies into site closure and corrective action alternatives for OU4 that represent a range of treatment and containment combinations, as appropriate.
5. Screen the assembled alternatives in terms of the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo thorough and extensive analysis, alternatives will be evaluated in less detail than subsequent evaluations.
6. Develop preliminary cancer risk-based remedial action goals for affected media. Preliminary remedial action goals will be applied as performance objectives for evaluating the effectiveness of specific technology processes identified as candidate components of viable remedial action alternatives. Consistent with the NCP, preliminary remediation goals will be established at a 1×10^{-6} excess cancer risk point of departure evaluated at the source. As the CMS/FS evolves, preliminary remediation goals may be revised to a

different risk level on the basis of consideration of appropriate factors that include, but are not limited to, exposure, uncertainty, and technical issues.

7. Remediation goals associated with toxic, non-cancer risk will be determined using the appropriate reference dose for each chemical present on the site. A Hazard Index (HI) will then be calculated. If the HI exceeds 1.0, further investigation of preliminary remediation goals will be evaluated. If the HI is less than 1.0, a toxic risk does not exist at the site and remediation would not be required.

For the Phase I RFI/RI Work Plan, the appropriate level of alternatives analysis is the listing of general response actions most applicable to the type of site under investigation. General response actions are defined as those broad classes of actions that may satisfy the objectives for remediation defined for OU4. Table 5.1 provides a list and description of general response actions and typical technologies associated with remediating soils, ground water, and surface water. Table 5.1 also includes a general statement regarding the applicability of the general response action to potential exposure pathways. Not all of the alternative response actions and typical technologies listed may be appropriate for OU4. Some will be discarded during the screening of alternatives.

The response actions outlined in Table 5.1 must be applied to the potential exposure pathways that will be identified for OU4. The response actions can be capable of providing control over all or some of the potential pathways. Partially effective response actions can be combined to form complementary sets of response actions that provide control over all pathways.

In general terms, potential human exposure can be avoided by prevention of contaminant release, transport, and/or contact. Thus, application of the response actions may be considered at three different points in each potential exposure pathway (1) at the point where the contaminant could be released from the source, (2) in the transport medium, and (3) at the point where the contact could occur with the released contaminant.

The existing data do not adequately characterize the source, release mechanisms, and migration pathways for contamination at OU4. Therefore, the existing data are not sufficient for implementing the screening of alternatives. Phase I will generate data (Table 5.2) necessary to characterize the source and soils (as defined in Section 1.0). Phase II of the RFI/RI will evaluate the impact of OU4 on surface water, ground water, air, the environment, and biota in addition to characterizing potential contaminant migration pathways. Data obtained from these investigations will:

- Describe the physical characteristics of the site

- Define sources of contamination
- Determine the nature and extent of contamination in soil, ground water, surface water, and air
- Describe contaminant fate and transport
- Describe receptors.

These data will provide information for the preliminary screening of alternatives and a thorough, comparative evaluation of the technologies with respect to implementability, effectiveness, and cost. This information will allow for informed decisions to be made with respect to the selection of preferred technologies. The FSP (Section 7.0) describes the methodology that will be followed to obtain the required information for the Phase I RFI/RI characterization.

5.7.2 Detailed Analysis of Remedial Alternatives

Sufficient data may not be generated during the Phase I investigation to allow for a detailed analysis of alternatives. The detailed analysis of each alternative will be performed when sufficient data are generated during Phase II. The detailed analysis and selection of alternatives is the process of analyzing and comparing relevant information in order to select a preferred remedial action. In accordance with the NCP, containment technologies will generally be appropriate remedies for wastes that pose a relatively low-level threat or where treatment is impracticable. Each appropriate alternative will be assessed in terms of nine evaluation criteria, and the assessments will be compared to identify the key attributes among the alternatives. Assessment in terms of eight evaluation criteria is necessary for the CMS and the subsequent Corrective Action Decision (CAD)/Record of Decision (ROD). The nine specific evaluation criteria are as follows:

1. Overall protection of human health and the environment
2. ARARs
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume
5. Short-term effectiveness
6. Implementability
7. Cost
8. State acceptance
9. Community acceptance.

These criteria are described in recently revised guidelines provided in the NCP. The first two criteria are considered threshold criteria because they must be evaluated before further consideration

of the remaining criteria. The next five criteria are considered the balancing criteria on which the analysis is based. The final two criteria are addressed during the final decision-making process after completion of the CMS/FS.

5.8 TASK 8 - TREATABILITY STUDIES/PILOT TESTING

The primary purposes of a treatability study are to provide sufficient technology performance information and to reduce cost and performance uncertainties to acceptable levels so that treatment alternatives can be fully developed and evaluated during detailed analysis. The task includes efforts to evaluate whether treatability studies are necessary and, if so, to prepare for and conduct treatability studies. If remedial alternatives are developed, the data collected as part of the field investigation will be reviewed in terms of whether the alternatives can be evaluated. If additional data are required, treatability studies or field investigations will occur.

If it is determined that a treatability study is necessary, a treatability work plan will also be prepared. The plan will identify treatability tests that need to be conducted as well as the test materials and equipment needed.

The treatability work plan will discuss the following:

- Results of treatability studies at other OUs
- The scale of the treatability study
- Key parameters to be varied and evaluated, and criteria to be used to evaluate the tests
- Specifications for test samples, and the means for obtaining these samples
- Test equipment and materials, and procedures to be used in the treatability test
- Identification of where and by whom the tests and any analytical services will be conducted, as well as any special procedures and permits required to transport samples and residues and conduct the test
- Methods required for residue management and disposal
- Any special QA/QC needed for the tests.

5.9 TASK 9 - PHASE I RFI/RI REPORT

The Phase I RFI/RI report will be prepared to consolidate and summarize the data obtained during the Phase I fieldwork as well as data collected from previous and ongoing investigations. The

Phase I RFI/RI report will consist of a Preliminary Site Characterization Summary and a BRA of the Solar Ponds area and adjacent vadose-zone soils. This report will:

- Describe the field activities that serve as a basis for the Phase I RFI/RI report. This will include the scope of the Phase I investigation and any deviations from the Work Plan that occurred during implementation of the field investigation.
- Discuss site physical conditions based on existing data and data derived during the Phase I RFI/RI. This discussion will include surface features, climate, surface water hydrology, surficial geology (vadose-zone soils), geotechnical soil index properties and classification, stratigraphy, ground water hydrology, demography and land use, and ecology.
- Present site characterization results from all Phase I RFI/RI activities to characterize the site physical features and contamination at OU4. The media to be addressed will be limited to contaminant source and soils.
- Discuss contaminant fate and transport based on existing information. This discussion will include a preliminary identification of potential contaminant migration routes, release sources and mechanisms, and a discussion of contaminant persistence, chemical attenuation processes, and potential receptors.
- Present a Phase I BRA. The BRA will include human health and environmental evaluations.
- Present a summary of findings and conclusions.
- Identify data needs for Phase II of the RFI/RI, if necessary.

Before submittal of the Phase I RFI/RI report, a Preliminary Site Characterization Summary will be submitted to EPA and CDH for review. This summary will provide an early description of the initial site characterization effort, including a preliminary presentation of analytical data and a listing of chemical and radiological contaminants, the affected media, and potential sitewide chemical-specific ARARs. In addition to the characterization summary, technical memoranda will be prepared with the completion of each field sampling task to provide preliminary results of field investigations.

TABLE 5.1

GENERAL RESPONSE ACTIONS, TYPICAL ASSOCIATED REMEDIAL TECHNOLOGIES, AND EVALUATION

General Response Action	Description	Typical General Response Technologies	Action to Potential Pathways
No Action	No remedial action taken at site	Some monitoring and analyses may be performed.	National Contingency Plan requires consideration of no action as an alternative. Would not address potential pathways, although existing access restriction would continue to control on-site contact.
Access and use restrictions	Permanent prevention of entry into contaminated area of site. Control of land use.	Site security; fencing, deed use restrictions; warning signs.	Could control on-site exposure and reduce potential for off-site exposure. Some site security fencing and signs are in place. Additional short-term or long-term access restrictions would likely be part of most remedial actions.
Containment	In-place actions taken to prevent migration of contaminants.	Capping; ground water containment barriers; soil stabilization; enhanced vegetation.	If applied to source, could be used to control all pathways. If applied to transport media, could be used to mitigate past releases (except air).
Pumping	Transfer of accumulated subsurface or surface contaminated water, usually to treatment and disposal.	Ground water pumping.	Applicable removal of contaminated ground water.
Removal	Excavation and transport of primarily nonaqueous contaminated material from area of concern to treatment or disposal area.	Excavation and transfer of soils, contaminated structures.	If applied to source, could be used to control all pathways. If applied to transport media, will control corresponding pathway. Must be used with treatment or disposal response actions to be effective.
Treatment	Application of technology to change the physical or chemical characteristics of the contaminated material. Applied to material that has been removed.	Solidification; biological, chemical, and physical treatment.	Applied to removed source material; could be used to control all pathways. Applied to removed transport media, could control air, surface water, ground water, and sediment pathways.

TABLE 5.1 (continued)

GENERAL RESPONSE ACTIONS, TYPICAL ASSOCIATED REMEDIAL TECHNOLOGIES, AND EVALUATION

General Response Action	Description	Typical General Response Technologies	Action to Potential Pathways
In-Situ Treatment	Application of technologies in-situ to change the in-place physical or chemical characteristics of contaminated material.	In-situ vitrification; bio-remediation.	Applied to source, could be used to control all pathways. Applied to transport media, could be used to control corresponding pathways.
Storage	Temporary stockpiling of removed material in a storage area or facility prior to treatment or disposal.	Temporary storage structures.	May be useful as a means to implement removal actions, but definitely would not be considered a final action for pathways.
Disposal	Final placement of removed contaminated material or treatment residue in a permanent storage facility.	Permitted landfill; repositories.	With source removal, could be used to control all pathways. With removal of contaminated transport media, could be used to control corresponding pathway (except air).
Monitoring	Short-and/or long-term monitoring is implemented to assess site conditions and contamination levels.	Sediment, soil, surface water, and ground water sampling and analysis.	RCRA requires post-closure monitoring to assess performance of closure and corrective action implementation.

TABLE 5.2

RESPONSE ACTIONS, REMEDIAL TECHNOLOGIES, AND DATA REQUIREMENTS

General Response Actions	Associated Remedial Technologies	Data Purpose	Data Need
Complete or partial removal and treatment of contaminated soils	• Disposal (off-site)	Evaluate RCRA land ban and radioactivity restrictions	<ul style="list-style-type: none"> - 40 CFR 268 Table CCWE and Appendix III Analyses - Full suite of radionuclide analyses
		Cost analysis	<ul style="list-style-type: none"> - Vertical and horizontal extent of contamination
In-situ contaminated soils treatment	• Immobilization	Determine viscosity of grout material	<ul style="list-style-type: none"> - Soil grain size distribution (sieve analysis)
		Effectiveness	<ul style="list-style-type: none"> - Full suite of organic and inorganic analyses
	• Soil flushing	Effectiveness	<ul style="list-style-type: none"> - Full suite of organic and inorganic analyses - Soil organic matter content - Soil classification - Soil permeability - Treatability study
		Effectiveness	<ul style="list-style-type: none"> - Full suite of organic and inorganic analyses - Subsurface geological characteristics - Depth to ground water - Soil permeability - Treatability
	• Vapor extraction	Effectiveness	<ul style="list-style-type: none"> - Full suite of organic and inorganic analyses - Subsurface geological characteristics - Depth to ground water - Soil permeability - Treatability
Ground water collection	• Vitrification	Cost effectiveness	<ul style="list-style-type: none"> - Full suite of organic and inorganic analyses - Treatability study
	• Well array/subsurface drains	Storativity (transient flow)	<ul style="list-style-type: none"> - Aquifer tests

TABLE 5.2 (continued)

RESPONSE ACTIONS, REMEDIAL TECHNOLOGIES, AND DATA REQUIREMENTS

General Response Actions	Associated Remedial Technologies	Data Purpose	Data Need
Infiltration and ground water containment controls	• Capping/subsurface barriers	Suitability of off-site soil for use	<ul style="list-style-type: none"> - Gradation (sieve analysis) - Atterberg limits (plasticity tests) - Percent moisture - Compaction (proctor) - Permeability (triaxial permeability) - Strength (triaxial or direct shear)
		Effectiveness	<ul style="list-style-type: none"> - Location of subcropping sandstones - Hydraulic conductivity of bedrock materials
		Construction feasibility	<ul style="list-style-type: none"> - Grade - Depth to bedrock
In-situ ground water treatment/immobilization	• Immobilization	Determine viscosity of grout material	<ul style="list-style-type: none"> - Soil grain size distribution (sieve analysis)
		Effectiveness	<ul style="list-style-type: none"> - Full suite of organic and inorganic analyses
	• Aeration	Effectiveness	<ul style="list-style-type: none"> - Full suite of organic and inorganic analyses - Subsurface geological characteristics - Depth to ground water - Soil permeability - Treatability study

TABLE 5.2 (continued)

RESPONSE ACTIONS, REMEDIAL TECHNOLOGIES, AND DATA REQUIREMENTS

General Response Actions	Associated Remedial Technologies	Data Purpose	Data Need
Ground water/surface water treatment	• UV/peroxide or UV/ozone	Process control	- Iron and manganese
		Effectiveness	- Full suite of organic and inorganic analyses - Treatability study
	• Air stripping	Process control	- Hardness
		Effectiveness	- Full suite of organic and inorganic analyses - Treatability study
	• Other water treatment technologies (carbon adsorption, ion exchange, electrodialysis, and reverse osmosis)	Process control	- Full suite of organic and inorganic analyses
		Effectiveness	

6.0 SCHEDULE

A preliminary schedule for conducting the Phase I RFI/RI is summarized in Figure 6-1. Dates shown are from the IAG, dated January 22, 1991. According to the schedule, approximately 22 months will elapse from the time this Work Plan is finalized until the Phase I RFI/RI report is issued.

The schedule indicates field activities continuing until August 1992. The schedule and completion of field activities are contingent on the cleanout of the ponds. The Solar Ponds (OU4) are currently in an IM/IRA process which will expedite the dewatering of liquids and removal of sludge from the ponds. Furthermore, the ponds' liners will require surficial cleaning/decontamination prior to commencing field activities which are planned to occur within the ponds.

		1990												1991												1992												1993																			
		J	F	E	M	A	M	J	J	A	I	S	O	N	D	J	F	E	M	A	M	J	J	A	I	S	O	N	D	J	F	E	M	A	M	J	J	A	I	S	O	N	D	J	F	E	M	A	M	J	J	A	I	S	O	N	D
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Phase I RFI/RI Report																																																									
009.																																																									
ES 18NOV92 EF 18OCT93																																																									

Activity Bar/Early Dates

Critical Activity

Progress Bar

Sheet 1 of 1

U.S. Dept. of Energy, Rocky Flats

Phase I, RFI/RI for Operable Unit #4

FIGURE 6-1

Data Date: 2JAN90

Plot Date: 20NOV91

Primavera Systems, Inc. 1984-1991

7.0 FIELD SAMPLING PLAN

The purpose of this section of the Work Plan is to provide a Field Sampling Plan (FSP) which outlines the activities which will generate sufficient and adequate data to satisfy the Phase I RFI/RI objectives developed in Section 4.0. These site-specific objectives are presented in Section 7.1. Current site conditions and a discussion of the rationale for the sampling and analysis activities needed to obtain the necessary data to meet the Phase I objectives are summarized in Section 7.2.

The proposed field sampling program has been organized by geographic location. The sampling activities proposed to meet the Phase I RFI/RI objectives for each location are presented in Section 7.3. Sampling activities include:

- Installation of upgradient ground water monitoring wells
- Site-wide radiological survey and surficial soil sampling
- Site-wide vadose zone monitoring
- Field sampling and geophysical investigation in the vicinity of the Original Pond
- Field sampling and geophysical investigation of the existing Solar Ponds area
- Field sampling and investigation of the Interceptor Trench System and site remainder.

This geographic approach is intended to allow flexibility in implementing the Phase I sampling program concurrent with Interim Measure/Interim Remedial Action (IM/IRA) activities and Pondcrete activities for Pond liquids and sludge removal.

The analytical program, including sample designations, analytical requirements, sample containers and preservations, sample labeling and documentation is discussed in Section 7.4. Data management and reporting requirements are described in Section 7.5, and Field QC Procedures in Section 7.6. Air Monitoring Surveillance activities are described in Section 7.7. Health and Safety concerns for the Phase I RFI/RI will be addressed in a project-specific Health and Safety Plan, developed at a later date in accordance with EG&G's site-wide Health and Safety Program.

Phase II of the RFI/RI will use the characterization of source and soils information obtained in Phase I and will determine the nature and extent of contamination, describe contaminant fate and

transport, and evaluate the impact of OU4 on surface water, ground water, air, and biota. Phase II activities will be addressed in a separate Work Plan.

7.1 OU4 PHASE I RFI/RI OBJECTIVES

The specific objectives for characterizing source and soils in the Phase I RFI/RI field investigation for OU4 are as follows:

Characterize Original and Existing Solar Ponds

1. Characterize location, type of contaminants, variation in contaminants and other unique characteristics of the Original Pond.
2. Evaluate relative significance of pond liner material as potential sources of contamination, and effectiveness of liners as barriers to contaminant migration.
3. Characterize surficial soil in vicinity of ponds potentially contaminated by aerosol dispersion.
4. Characterize location and type of contaminants, variation in contaminants, and other unique characteristics of vadose zone contamination in the Solar Ponds area.
5. Provide upgradient ground water monitoring wells to serve as a basis for comparison to contaminant concentrations in ground water downgradient of the ponds.
6. Locate and identify subsurface features such as piping, tanks or structures in the vicinity of the Solar Ponds.
7. Identify subsurface geologic structures that provide a potential pathway for contaminant migration in the Solar Ponds vicinity, including subcropping sandstones and fractured bedrock.

Characterize Interceptor Trench System

1. Evaluate the construction of the Interceptor Trench System (ITS) in an attempt to determine effectiveness in intercepting Solar Pond contaminants in ground water.
2. Characterize location, type of contaminants, and variability in contaminant concentration in unconsolidated materials in the vicinity of the ITS.

Provide a Baseline Risk Assessment

The objectives of the Baseline Risk Assessment are discussed in Sections 8.0 and 9.0.

Determine Nature and Extent of Contamination

This will be addressed in the Phase II RFI/RI Work Plan

Determine Contaminant Fate and Transport

This will be addressed in the Phase II RFI/RI Work Plan

Another objective of the Phase I RFI/RI Work Plan is to generate data necessary to begin development and screening of remedial alternatives, and to evaluate the need for the performance of treatability studies. Similarly the data will be used to determine risks to human health and the environment associated with Solar Pond contaminants.

7.2 BACKGROUND AND FIELD SAMPLING PLAN RATIONALE

Previous investigations performed in the Solar Ponds area and other pertinent information are summarized in Section 2.0 of this Work Plan. Numerous investigations have been performed previously at the Solar Ponds to characterize pond liquids, sludge, and contaminants in soil, ground water, surface water, and air quality in the vicinity. Available information at the site includes historical information on Solar Pond construction and use, aerial photographs, historical and current liquids and sludge analytical results, soil sample results from borings constructed in the area of the ponds, stratigraphic logs, ground water level measurements, ground water analytical results from alluvial and bedrock wells in the vicinity of the ponds, surface water sample analytical results from seeps and air monitoring results. As-built drawings of the ITS and analytical results from liquid samples collected from manholes in the ITS are also available.

Few previous investigations have provided information on physical characteristics of the site such as subsurface piping, geologic structures, or specifics regarding ITS configuration and effectiveness. Geophysical investigations, advanced borehole drilling and piezometer installation are proposed in this Phase I RFI/RI to provide information on physical site characteristics.

Only a small portion of the data for Solar Ponds area are known to be reliable or have been validated. Most of the data is currently undergoing a validation process, and some soil boring analysis results have already been rejected for laboratory QA reasons. All available data were used to evaluate contaminant location and characteristics in this Work Plan, although most recent data were relied upon more heavily since a higher level of documented quality is associated with the more recent results.

The sampling plan discussed in Section 7.3 differs somewhat from the plan devised in the Draft Phase I RFI/RI Solar Ponds investigation. The rationale for major components of this revised Field Sampling Plan are presented in the following paragraphs.

Field Sampling Plan Rationale

The liquid and sludge in the ponds will not be sampled in the Phase I effort. These contaminant sources have been characterized to the extent possible through historical and recent sampling, and they will be removed from the site. Prior to initiating field work within the ponds, the pond liners will be decontaminated with steam cleaners after the liquids and sludge are removed, and the relative significance of these liners as secondary sources of contamination will be evaluated in the Phase I Program through field screening. Additional characterization of the pond liners will depend on the results of the field screening. At this time, it is considered that analysis of the asphalt pond liner materials would be appropriate if the liners are to be characterized for waste disposal. However, the usefulness and accuracy of chemical analysis of the asphalt liner material for purposes of characterizing contaminant sources in this Phase I RFI/RI is very limited.

Preliminary review of data indicate surficial soil contamination may exist in the vicinity of the Solar Ponds. Radionuclides present in soil samples collected near the Solar Ponds are perhaps indicative of aerosol dispersion from the ponds, an observation which prompted the development of a site-wide surficial radiological survey for alpha and gamma/beta radiation. In addition, previous analytical data did not provide an accurate representation of surficial contamination from radionuclides, metals or other pond contaminants, because near surface samples included soils collected at depths of 2 to 5.8 feet from the surface. Therefore, a randomly chosen subset of these radiological survey points will also be selected for surficial sampling and laboratory analysis. This randomly chosen subset will allow correlation of the magnitude of radiological screening measurements with laboratory analyses of specific radionuclide occurrence and concentration throughout the OU.

Ground penetrating radar is proposed in the Solar Ponds area to define subsurface features such as piping, tanks, changes in lithology that could possibly delineate the location of the Original Pond, and to provide nonintrusive information on geologic strata and structures underlying the site. The rationale for selecting these methods is presented in appropriate subsections of this FSP.

Vadose zone monitoring techniques using lysimeters, tensiometers, or in situ soil vapor monitoring instruments will be further investigated for use throughout the Solar Ponds area. Early research on

these methods indicates the potential for investigating infiltration, contaminant leaching, and ground water transport.

Radiological compounds in unconsolidated materials are also an indication of Solar Pond contamination. Radionuclides were detected in subsurface soil samples and ground water samples, and are thought to be attributed to Solar Pond contamination. Radiological screening will be conducted on soil cores from unconsolidated material boreholes to provide an indication of subsurface radiation, and to screen samples to be submitted for laboratory radiochemistry analysis. Downhole geophysics are also proposed to log gamma radiation with respect to depth.

Unconsolidated materials sampling will be conducted under the pond liners, in areas surrounding the ponds, and in the vicinity of the ITS. Data considered pertinent to characterization of source and soils are historical waste stream information and previous analytical results from the pond liquids and sludge, as well as new data collected to evaluate the release of contaminants to the underlying, undisturbed soil. Sampling of the pond liners themselves is not proposed in this investigation, as the liners are not considered primary sources of Solar Pond contaminants. Removing the liquids and sludge will eliminate the primary sources of contaminants. The relative significance of the liners as remaining sources of residual contamination after the liquids and sludge are removed will be evaluated in the field using radiological and volatile organic compound screening equipment. Sampling of pond liner materials may be proposed pending results of field screening activities.

The installation of piezometers in the ITS area is proposed in this Work Plan to assist in characterizing the effectiveness of the drain in intercepting contaminated ground water. Piezometer installation will allow the hydrologic system near the main interceptor trench to be further understood, by providing water level information at several locations.

Upgradient monitoring wells will be installed in this Phase I RFI/RI to provide a basis to compare downgradient ground water quality. Although characterization of site ground water is not within the scope of the Phase I investigation, wells will be installed in response to a request from the Colorado Department of Health.

The rationale for the Phase I sampling activities is based on an iterative process. Level I and Level II data types will initially be acquired and used to direct subsequent intrusive sampling techniques

that will provide Level III through V analytical results. A visual survey of pond liner condition will guide the placement of vadose zone boreholes within the ponds. Similarly, vadose zone monitoring results may be used to guide further soil and ground water investigations.

As part of the field sampling program, data from the sitewide monitoring program will be used as appropriate to supplement the data collected during the Phase I investigation. These data include the results of quarterly sampling of existing monitoring wells and monthly sampling of surface water monitoring stations. Data resulting from the site-wide geologic characterization program will also be used, where possible. Air monitoring activities conducted site-wide or in specific response to the Pond Liquids and Sludge Removal activities will also be included.

Analytical Methods Rationale

The analytical suites for each area in OU4 were developed according to the type of waste suspected to be present in each area. The rationale for the analytical suites is based on historical information regarding types of contaminants detected or reportedly disposed in the Solar Ponds. Because the field sampling program may be implemented in some locations before others, the analytical suites proposed in this Work Plan may be revised based on results of initial field efforts. Any changes to the analytical suite will need to be reviewed, proposed and accepted before any change will be implemented.

7.3 FIELD SAMPLING PLAN DESIGN

The Phase I sampling activities at the Solar Ponds are discussed as six related, but independent programs. They include:

1. Installation of upgradient ground water monitoring wells (Section 7.3.1)
2. Site-wide radiological survey and surficial sampling program (Section 7.3.2)
3. Site-wide vadose zone monitoring (Section 7.3.3)
4. Determination of location and contaminant distribution in the Original Pond (Section 7.3.4)
5. Determination of vadose zone contamination and subsurface features associated with existing Solar Ponds (Section 7.3.5)
6. Investigation of unconsolidated materials and water table configuration in vicinity of the ITS and in remainder of the site (Section 7.3.6).

A review of aerial photographs and other recently collected data will be conducted prior to commencing any field work mentioned above.

7.3.1 Upgradient Ground Water Monitoring Well Installation

To provide ground water quality data upgradient of the Solar Ponds, two well clusters with individual wells screened in the alluvium, weathered bedrock, and unweathered bedrock ground water systems will be installed. These wells are being installed as part of the Phase I RFI/RI program to comply with a specific request by the Colorado Department of Health. The proposed location of the well clusters is shown on Figure 7-1. Locations were chosen using the ground water flow system depicted in Figures 2-17 through 2-20, which indicate a ground water flow direction to the east. Screened intervals within the alluvium, weathered bedrock and unweathered bedrock will be selected on the basis of most recent ground water level information obtained from RCRA site-wide monitoring. The proposed cluster well locations were checked against the Comprehensive List of Waste Management Units (U.S. DOE, 1986c). None of these proposed locations are within or immediately downgradient of an IHSS.

Monitor well installation procedures will be in accordance with SOP GT.6. Hollow-stem augers will be used for well installation. During the drilling operation, the cuttings and formation water from the boring will be placed in environmental materials drums if required by procedures in SOP FO.8, Handling of Drilling Fluids and Cuttings. Bedrock wells will be isolated from the overlying units with surface casing that has been pressure grouted in accordance with SOP GT.6. Documentation required for installation of ground water monitoring wells will follow the guidelines established in SOP GT.6. To minimize the potential for contamination caused by drilling activities, decontamination of drilling equipment will be conducted between zones and between wells in accordance with SOPs F0.3, and F0.4. During drilling, airborne contaminant dispersion will be minimized in accordance with SOP F0.1. A list of SOPs, which are relevant to this Phase I Work Plan, is contained in Section 11.0.

One round of ground water samples will be collected from the upgradient cluster wells during the Phase I RFI/RI. Subsequent sampling events will be conducted under the site-wide ground water monitoring systems plan. Well development, ground water sampling and measurement of field parameters will follow procedures outlined in SOPs GW.2, GW.5 and GW.6. Ground water samples will be placed in appropriate containers for analytical testing according to SOP F0.13 Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples. Ground water samples will be

analyzed for the full suite of parameters analyzed in the site-wide RCRA monitoring program. A discussion of the analytical program for ground water samples is provided in Section 7.4.

7.3.2 Site-Wide Radiological Survey and Surficial Sampling Program

Historically, Pond 207-A was used for disposal of liquids containing relatively high levels of the radionuclides plutonium and americium. A preliminary radiation survey conducted on the Pond 207-A perimeters in August 1990 indicated elevated alpha readings confirming historical data regarding high radionuclide content in Pond 207-A liquids and sludge. Based on this information, a surface radiological survey is proposed to characterize low level radionuclide distribution throughout the area.

A site-wide radiological survey using alpha and gamma/beta radiation meters will be conducted on a grid system established throughout the Solar Pond area. The radiological survey will be conducted based on procedures modified from SOP F0.16. If needed, a Document Change Notice (DCN) will be developed prior to implementation. A 100-foot square grid will be established in the Solar Ponds area, extending from Building 771 on the west to the easternmost interceptor trench on the east, and from 1,500 feet south of the ponds to north of the ITS. The Perimeter Security Zone (PSZ) bisects this area, however, the grid will not be established inside the PSZ. Radiation measurements will be taken at all nodes of the established grid. In the Solar Pond area south of the PSZ, measurements will be increased to include a supplemental point at the center of each 100-foot grid square. Measurements are proposed at approximately 350 locations in the surface radiological survey, depicted on Figure 7-2. The radiological survey will be conducted in coordination with activities at adjacent operable units to minimize duplication of effort.

Prior to conducting the survey, the survey points will be paced and/or taped off. If a structure or other obstruction makes conducting measurements at the node difficult, the survey location will be moved to the closest location where readings may be taken. Additional survey points may be established in the field in areas suspected of having elevated radionuclides, including surface water seep locations and pond liner cracks. After measurement, locations will be surveyed using standard land surveying techniques. Field team members will coordinate with ongoing operations personnel to ensure that stakes or flagging used to identify sampling locations are not moved or damaged by ongoing waste operations prior to surveying.

The survey will be conducted using a Ludlum Model 12-1A alpha monitor with an air proportional probe, or equivalent, and a high-purity germanium gamma-ray sensor. Calibration of the instruments will be conducted daily.

The survey may be conducted in phases as access to areas such as the cleaned ponds becomes feasible. Each grid node will be identified with a unique station number using alphabetical and numeric grid identifiers such as A-1 or B-3 where letters are assigned to rows and numbers assigned to columns. Any survey readings taken at nonstandard grid locations will also be given a unique identifier.

The gamma probe will be held at waist level and readings will be recorded at each location based on the number of counts displayed on the instrument after one minute. Alpha radiation is measured much closer to the soil than gamma radiation. The alpha counter will be held 4 to 6 inches off ground surface and a minimum of two readings will be taken at each grid node. Alpha readings will be collected at eight locations equidistant around a five foot radius circle at the surveyed location. The eight readings will be recorded and the highest and lowest value identified. Gamma and alpha readings will be recorded on data sheets which can be related to field location maps. The data sheet to be used is Form F0.16A, which is contained in SOP F0.16. Additional readings may be collected at anomalously elevated areas, although no more than 50 additional survey locations will be added.

Surficial Sampling

One out of every ten radiation survey locations will be selected for surficial soil sample collection. Approximately 35 surficial soil samples will be collected and analyzed. Although the sampling locations will be disturbed uniformly over the area, the precise location of each sample will be selected at random. Randomized sample collection will allow subsequent correlation of radiation survey measurements with laboratory analyses of specific radionuclide occurrence and concentration. Methods for selecting random sample locations will be evaluated as part of the Phase I RFI/RI Project Planning Task.

In accordance with procedures in SOP GT.8, two one-meter square areas located one meter apart will be established at each surficial sampling location. If asphalt or other barriers prevent the collection of a surficial sample, the location will be moved to the closest accessible location. From the two square meters, a minimum of five soil samples will be collected from each of the corners and the center of each square meter. Additional subsamples may be collected in order to obtain a

sufficient sample volume for analysis. Samples will be collected to a 1 inch depth with either a plug type sampler, or a stainless steel scoop. The subsamples will be composited in a large stainless steel bowl or pan and stirred with a stainless steel scoop or spoon. Sample handling will be conducted in accordance with SOP FO.13, Containerizing, Preserving, Handling, and Shipping Soil and Water Samples. Sampling equipment will be decontaminated between individual sampling points in accordance with SOP FO.3, General Equipment Decontamination. Documentation of the surficial soil sampling activity at the Solar Ponds will be in accordance with SOP GT.8.

7.3.3 Site-Wide Vadose Zone Monitoring

Vadose zone monitoring may be achieved through the use of nested lysimeters, tensiometers or in situ soil vapor instruments such as the BAT[®] system. Initial research on the subject indicates that delineation of migration patterns in soil may be possible through vadose zone monitoring. Such monitoring represents an innovative and cost effective means of delineating potential contaminant migration pathways. Although specific monitoring locations and methods have not been identified, it is likely that all areas of concern within the Solar Ponds area will be monitored. Significant additional research on the applicable techniques will be required as part of the Phase I RFI/RI Project Planning task to better define the specifics of the monitoring program. A general overview of vadose zone monitoring techniques may be found in the Practical Handbook of Ground Water Monitoring (Nielsen, 1991). If deemed appropriate, vadose zone monitoring will be incorporated in the Solar Ponds area and SOPs will be developed prior to implementation. The SOPs will include upgradient monitoring to allow comparison of the data.

7.3.4 Original Pond Area

Proposed field activities and a geophysical investigation at the Original Pond area are shown on Figure 7-3. In order to define the boundaries of the Original Pond, activities proposed in this section will be preceded by an aerial photograph review, engineering drawings review, and evaluation of other historical documentation. A surface radiological survey and surficial soil sampling program will be conducted as described in Section 7.3.2. Subsequent field activities include a geophysical survey and drilling of four boreholes through the unconsolidated materials with collection of subsurface samples for chemical analysis. Each of these activities is described below.

7.3.4.1 Geophysical Investigation

A surface geophysical investigation employing ground penetrating radar (GPR) will be performed in the area on and around the Original Pond. The survey will be conducted in accordance with guidelines provided in SOP GT.18. The primary objectives of this survey are to locate the boundaries of the Original Pond, and to locate any piping or other fittings not removed at the time the pond itself was removed. An inventory of RFP piping and its configuration is currently being compiled in the Original Process Waste Lines (OPWL) investigation. Preliminary information reviewed from the OPWL investigation shows underground piping and possibly tanks in the immediate vicinity of the Original Pond. It must be noted that the abundance of cultural features throughout OU4 may limit the results of the proposed geophysical investigation.

Theory of Operation

Ground Penetrating Radar (GPR) utilizes an electromagnetic pulse source, source and receiver antennas, and a graphic recorder to map reflections from subsurface interfaces caused by buried objects and distinct stratigraphic horizons. For a reflection to occur, an impedance contrast, which is related to the dielectric constant and conductivity of the respective materials, must be present across any such interface(s).

The GPR instrument consists of a microprocessor-based control unit, a graphic recorder, and a combined source/receiver antenna. These components are interconnected through a series of cables which:

- Carry power to the antenna
- Relay reflected electromagnetic pulses from the antenna to the control unit
- Transfer processed electromagnetic pulses from the control unit to the graphic recorder.

A number of antennas are available at frequencies which range from 80 Megahertz (Mhz) to 900 Mhz. Typically, a lower frequency antenna, such as 80 Mhz, will permit greater signal penetration but with less resolution, whereas a higher frequency antenna, such as a 900 Mhz, offers greater resolution but with less signal penetration. The depth of underground piping or any remaining clay liner material from the Original Pond will guide selection of antenna frequency.

GPR data is collected by slowly pulling the antenna across the ground surface. A paper record output by the graphic recorder during each of the "traverses" is annotated in the field with the traverse location, horizontal scale, full-scale time display, and the antenna used.

Field Methodology

The GPR survey design, field procedures and documentation of activities will follow those outlined in SOP GT.18. Prior to beginning GPR data collection, a grid will be surveyed on and around the reported location of the Original Pond. Use of the grid will permit the systematic collection of data from the area. After a survey is completed in the reported pond location, the grid will be expanded to the areas surrounding the existing Solar Ponds for subsequent data collection. Key points on the grid will be surveyed in and referenced to the site coordinate system. The approximate area included in the grid system is shaded in Figure 7-3.

Data will be collected by locating the GPR traverses on appropriate grid lines and the antenna pulled slowly along the surface. At least two antennas will be tested, with the one offering the best combination of target resolution and signal penetration being utilized for the survey. All GPR records will be annotated with the traverse location, horizontal scale, full-scale time display, antenna used, and the location of any anomalies observed. Also, the surface on which each traverse is located will be inspected for the presence of features which could cause an anomaly. Initial GPR records will be inspected closely to determine if the task objectives being accomplished. A recommendation will be made to EG&G personnel as to whether or not to proceed with GPR data collection.

Following GPR data collection, all anomalies observed will be indicated in two ways:

- Stakes will be placed in the ground along the periphery of the Original Pond as interpreted from the GPR records. Stakes will be placed in the ground above any lines, tanks or other objects, the location of which are interpreted from the GPR records.
- The locations of all objects indicated by stakes in the ground will be surveyed and accurately marked on a map of suitable scale.

The resultant map will be checked against known locations and uses of underground piping inventoried in the OPWL investigation. The relative importance of the presence of these subsurface features will be assessed. Any relative differences observed in areas within and outside of the Original Pond area will be used to guide unconsolidated material borehole placement and sampling.

After completion of the survey, all records collected will be compiled and filed for future reference.

7.3.4.2 Unconsolidated Materials Investigation

The unconsolidated material conditions in the vicinity of the Original Pond will be investigated by drilling boreholes, collecting soil samples and performing chemical analysis. The purpose of the borings is provide information on soil chemistry in near-surface and subsurface soils, identify old clay liner material (if present), provide information on depth to ground water, and provide information on weathered bedrock underlying the Original Pond, if encountered. Boreholes will be drilled at four locations in the Original Pond area. Preliminary borehole locations are shown in Figure 7-3, although the locations may be adjusted using results from the surface geophysical survey, radiological survey, and borehole clearing in accordance with SOP GT.10. Three borings will be placed within the reported Original Pond area, and one will be placed outside the pond location to provide a reference for evaluating whether effects from the Original Pond can be delineated.

To compliment the surficial soil sampling program described in Section 7.3.2, a surficial soil sample will be collected at each borehole location from the 0 to 1 inch interval. Concrete or asphalt encountered at borehole locations will be removed. Procedures for sample collection of the 0 to 1 inch interval are as described in Section 7.3.2.

Drilling will be performed using hollow-stem augers and unconsolidated materials will be continuously sampled. The unconsolidated material borehole locations will be cleared according to SOP GT.10, and installed using a truck-mounted and/or skid or trailer-mounted hollow-stem auger drilling rig, as may be required for access. A 2-foot-long continuous sampler will be used, and soil and bedrock cores will be geologically classified using both engineering Unified Soil Classification System (USCS) classifications and Soil Conservation Service (SCS) soil series identifiers. Drilling and sampling will follow procedures established in SOP GT.2. Airborne contaminant dispersion will be minimized in accordance with SOP F0.1. Logging the alluvial and bedrock material will be in accordance with guidelines specified in SOP GT.1 with the addition of SCS soil series horizon identification.

Boreholes will be advanced until either saturated soils are encountered or auger refusal. Total bedrock penetration in these borings will not exceed approximately five feet. This will be the general criteria for limiting the depth of boreholes except where delineation of the Arapahoe sandstones is an objective (see Section 7.3.5.3). An average total boring depth of 15 to 20 feet is envisioned. Soil cores will be collected at 2-foot increments to enhance sample recovery as described in SOP GT.2.

Each two-foot core will be screened while samples are being logged using hand-held field instruments for alpha and beta/gamma radiation, as well as VOCs according to SOP GT.1. A laboratory-quality alpha detector and sodium-iodide, beta/gamma detector that reads in counts per minute will be used. At a minimum, a photo-ionization detector will be used to detect VOCs emitting from samples. Results of the radioactive content and VOC screening may be used to alter standard interval selection for chemical analysis.

Samples will be composited from three 2-ft cores as described in SOP GT.2 and submitted for the parameters listed in Section 7.4.2. Samples will be selected at a minimum of 5-foot intervals from near the ground surface to the water table. Additional samples will be selected at changes in lithology and from zones that have indications of contamination as determined from visual inspection of the samples or field instrument screening for organics and radionuclides.

Geophysical borehole logging using gamma logs and other radiation detecting tools will be conducted at unconsolidated material boreholes, and in boreholes advanced for geologic investigation. Downhole logging may allow a more accurate representation of radionuclide distribution than soil core screening. Downhole logging will be conducted in accordance with SOP GT.15.

Collected samples will be placed in appropriate containers for analytical testing according to SOP FO.13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples. Radiation field screening and sample preparation for radiological analysis will be conducted in accordance with SOP FO.18. Vadose zone monitoring instruments may be emplaced into the subsurface prior to abandoning the boreholes.

Once all information is obtained from a subsurface boring, the borehole will be abandoned in accordance with SOP GT.5. Before proceeding to the next boring location, equipment will be decontaminated to avoid cross contamination in accordance with SOP FO.3, General Equipment Decontamination, SOP FO.4 Heavy Equipment Decontamination, and SOP FO.12 Decon Facility Operations. Environmental waste produced during drilling will be drummed and handled according to SOP FO.10.

7.3.5 Existing Solar Ponds Area

Proposed field activities and geophysical investigation at the existing Solar Ponds area are shown on Figure 7-4. Activities proposed in this section are preceded by a review of facility engineering

drawings, aerial photographs, the surface radiological survey and surficial soil sampling program described in Section 7.3.2. Field activities include a visual survey to determine locations of cracks in the pond liners, a geophysical survey to identify subsurface piping in the pond vicinity, and drilling of boreholes through the pond liner and on pond perimeters to investigate the unconsolidated materials below. Soil samples will be collected for chemical analyses in all unconsolidated material boreholes. Each of these activities is described below.

7.3.5.1 Visual Inspection

Prior to conducting the geophysical investigation, or intrusive borehole construction, a visual inspection will be conducted in the existing ponds area. The proposed perimeter borehole locations will be checked against the presence of obstructions, accessibility of the drilling rig, or other constraints not previously addressed. Once the liquids and sludge are removed from the Solar Ponds, the liners of all five ponds will be observed and cracks or other evidence of deterioration marked on a location map. Photographs of each pond will be taken to document deteriorated liner areas and general pond condition during the visual survey. The most damaged liner locations will be considered for sampling. Placement of unconsolidated material borings will be influenced by the results of the pond liner survey.

7.3.5.2 Geophysical Investigation

A ground penetrating radar (GPR) survey will also be performed in the areas surrounding the existing Solar Ponds. The objective of this survey is to locate piping and any other buried objects in the area. This survey will consist of an expansion of the survey performed in the Original Pond area and will employ similar instruments and techniques. The general vicinity of the Solar Ponds geophysical survey is shaded on Figure 7-4.

Field Methodology

The GPR survey design, field procedures, and documentation of activities will follow those outlined in SOP GT.18. The survey of the existing Solar Ponds area will follow the completion of the survey in the Original Pond area. The survey grid and parameters will be adjusted according to the results of the Original Pond survey. GPR data collection will be performed in the same manner as the survey in the Original Pond area.

7.3.5.3 Unconsolidated Material Investigation

The vadose zone investigation in the existing pond area will consist of borehole installation on the pond perimeters and within the ponds themselves. Twenty six borings are proposed in and around the existing Solar Ponds as shown on Figure 7-4. Five borings are proposed within Pond 207-A, and three are proposed in each of the remaining ponds. Ten perimeter borings will be placed on the pond exteriors. Boreholes constructed inside the ponds will be placed both at locations where cracks are observed, and where the liner integrity appears to be intact. Comparison of results from boreholes placed in such a manner may provide information to estimate patterns of pond leakage, including major contaminant migration pathways. Analytical results from the perimeter borings will be used to characterize lateral migration of pond contaminants in vadose zone soil. These perimeter borings will be placed in or as near pond embankments as is accessible.

The asphalt liners in the area of the borehole will be excavated with either an air driven or electric-powered jackhammer in an area of adequate size for sampling. The use of a jackhammer will not require introduction of water as is required with typical asphalt or concrete coring equipment. Base course material will be removed using a small shovel or other tool to reveal undisturbed alluvial material below. Health and Safety radiological and VOC measurements will be taken on removed liner and base course material using field screening instruments. Samples of the 0 to 1 inch depth interval will be collected from undisturbed material below the liners using the procedures described in the Surficial Soil Sampling Program, except that only one 1-meter square will be sampled.

A drilling investigation of unconsolidated materials will be performed as described in Section 7.3.2. A skid- or track-mounted drilling rig may be required due to limited pond access. Drilling depths are expected to vary from 15 to 20 feet for the boreholes inside and on the perimeters of the Solar Ponds. Proposed sample collection procedures and requested analytes are the same as those described for unconsolidated material borings in the Original Pond area. The proposed drilling procedure, sampling procedure and analytical suite are subject to revision or refinement based on results of unconsolidated material sampling conducted in other areas of the Solar Ponds.

A subset of the proposed borings in the Solar Pond area are to be advanced deeper than is described in standard drilling and sample collection procedures. The intent of drilling deeper boreholes is to collect geologic information on bedrock structures and stratigraphy underlying the ponds. Specific objectives are to delineate the location of the Arapahoe No. 1 sandstone in the pond vicinity and to determine the presence or absence of fractures in the bedrock. The total depths of these bedrock

borings will range from about 40 to 60 feet. Procedures for advancing these borings past the depth required for environmental sampling will follow guidelines in SOP GT.4, Rotary Drilling and Rock Coring.

7.3.6 Interceptor Trench System and Remainder of Site

Proposed field activities at the ITS and remainder of the site are shown on Figure 7-5. Activities proposed here are preceded by a review of system as-built drawings in Appendix A, and a surface radiological survey and surficial soil sampling program described in Section 7.3.2. Field activities include the installation of piezometers in several locations up and downgradient of the ITS to determine hydrological characteristics of the system, and drilling of boreholes in outlying areas of the ponds and in the ITS area to investigate the unconsolidated materials. Soil samples will be collected for chemical analyses in all unconsolidated materials boreholes.

A geophysical investigation employing seismic refraction and high resolution seismic reflection was considered for investigating the ITS and other selected portions of the site. However, a technical evaluation of these geophysical techniques found that the use of geophysics would be ineffective. The use of other investigatory methods, such as cone penetrometers, to determine the effectiveness of the ITS will be further considered and evaluated based on the results of this Phase I investigation.

7.3.6.1 Unconsolidated Materials Investigation

The unconsolidated materials investigation in the vicinity of the ITS and in outlying areas of the site will be accomplished with borehole construction and soil sampling. Borehole drilling and sampling procedures will be performed as discussed in previous sections. Figure 7-5 shows the proposed location for the 17 boreholes in the ITS area and remainder of site. The objective of drilling the borings is to provide soil contaminant information at relatively far distances from the ponds, and to compare soil contaminants in borings located up and downgradient of the ITS. Nine of the seventeen borings are located in the ITS area.

Selected boreholes in this area will also be advanced into the bedrock as described in Section 7.3.5.3. Boreholes will be advanced to a total depth range of about 40 to 60 feet in order to delineate the extent of sandstone lenses subcropping in the bedrock, and to investigate the presence or absence of bedrock fractures. Prior to drilling borings that advance into weathered bedrock, a surface casing will be installed according to SOP GT.3, Isolating Bedrock from the Alluvium with

Grouted Surface Casing. Each 2-foot core will be screened for alpha and beta/gamma radioactivity, as well as volatile organic compounds with field instruments while samples are being logged.

Contaminants likely to be detected in soil samples from these borings include those that are relatively soluble and were transported through ground water flow. For this reason, collecting soil samples immediately above the water table is a primary objective of these borings. Samples will be collected as described in Section 7.3.4.2.

7.3.6.2 Piezometer Installation

Piezometers will be installed immediately upgradient and downgradient of the primary interceptor trench to provide information on the water table configuration at the trench. Precise piezometer spacing will be determined using analytical modeling of aquifer drawdown to estimate the interceptor trench area of hydraulic influence. Measurement of water table configuration near the interceptor, and response to precipitation events, will allow evaluation of system effectiveness. The use of ground water tracers to monitor flow immediately toward and downgradient of the interceptor will also be considered following analysis of hydraulic data.

Piezometer installation procedures will be in accordance with SOP GT.6. Installation of the piezometers at three locations parallel to the assumed ground water flow direction is proposed, and at two locations perpendicular to flow direction. Piezometers installed perpendicular to flow will provide information on the finger trenches upgradient of the interceptor trench pump house. Water level measurements will be made in accordance with GW.1.

7.4 SAMPLE ANALYSIS

This section describes the sample handling procedures and analytical program for samples collected during the Phase I investigation. This section also includes discussions of sample designation, analytical requirements, sample containers and preservation, and sample handling and documentation.

7.4.1 Sample Designation

All sample designations generated for the RFI/RI will conform to the input requirements of RFEDs, as described in SOP FO.14A. Each sample designation will contain a nine-character sample number consisting of a two-letter prefix identifying the media samples (SB for soil boring, SS for surficial soils), a unique five-digit number, and a two letter suffix identifying the contractor. One sample

number will be required for each sample generated including QC samples. In this manner, 99,999 unique sample numbers are available for each sample media for each contractor that contributes sample data to the data base. Boring numbers will be developed independently of the sample number for a given boring. These sample numbering procedures are consistent with the RFP site-wide QAPjP.

7.4.2 Analytical Requirements

The analytical suites for surficial soil samples and unconsolidated material samples were developed according to the types of contaminants detected historically in the Solar Pond and adjacent areas, as well as their geochemical behavior. Specific analytes in the above groups and their CLP detection/quantitation limits are listed in Table 7.1. These analytes and limits should address the chemicals that have been previously detected in pond liquids and sludge, the sources for OU4.

Unconsolidated material samples from the Phase I RFI/RI collected in the Original and existing Solar Pond investigation will be analyzed for all of the following chemical and radionuclide parameters or parameter groups.

- Nitrate
- Target Analyte List (TAL) Metals
- Uranium 233/234, 235, 236 and 238
- Plutonium and Americium
- Cesium 137 and Strontium 90
- Gross Alpha and Gross Beta
- Tritium
- TCL volatile organics (subsurface samples only)
- TCL semivolatile organics
- Inorganics
- Pesticides.

Surficial soil samples will be analyzed for only a subset of these parameter groups including:

- Nitrate
- TAL Metals
- Uranium 233/234, 235, 236 and 238
- Plutonium and americium
- Cesium-137 and Strontium-90
- Gross alpha and gross beta
- Tritium.

A restricted suite of analyses will be conducted on unconsolidated material samples collected from within the interceptor trench system and the remainder of the site. The restricted analytical suite has been designed to characterize soil contaminants previously identified in these areas. Contaminants not previously observed above background concentrations in subsurface soils from these areas have been eliminated. In the event that sampling of the Original and existing Solar Pond Areas indicates that eliminated parameters may be of concern in unconsolidated soils of the Interceptor Trench System and the remainder of the site, the migration of these contaminants will be investigated further during Phase II of the RI/RFI.

The restricted suite of analyses proposed for unconsolidated material in the interceptor trench system and the remainder of the site include the following parameter groups:

- Nitrate
- Uranium 233/234, 235, 236 and 238
- Gross Alpha and Gross Beta
- Tritium
- TCL Volatile Organics
- Inorganics.

Ground water samples from the upgradient monitor wells will be analyzed for the full suite of compounds listed in Table 7.1. Also provided are the compounds CLP detection/quantification limits for water samples.

7.4.3 Sample Containers and Preservation

Sample volume requirements, preservation techniques, holding times, and container material requirements are dictated by the media being sampled and by the analyses to be performed. The soil matrices to be analyzed will include surficial soils and unconsolidated materials samples, and the water matrices for analysis will include ground water. Analytical parameters of interest in OU4 for water and soil matrices, along with the associated container size, preservatives (chemical and/or temperature), and holding times are listed in Table 7.2 and 7.3. Additional specific guidance on the appropriate use of containers and preservatives is provided in SOP FO.13, Containerizing, Preserving, Handling, and Shipping of Soil and Waste Samples. Information on preparing samples specifically for radiological analysis is provided in SOP FO.18.

7.4.4 Sample Handling and Documentation

Sample control and documentation is necessary to ensure the defensibility of data and to verify the quality and quantity of work performed in the field. Accountable documents include logbooks, data collection forms, sample labels or tags, chain-of-custody forms, photographs, and analytical records and reports. Specific guidance defining the necessary sample control, identification, and chain-of-custody documentation is discussed in FO.13.

7.5 DATA MANAGEMENT AND REPORTING REQUIREMENTS

The field data collected during the various investigations discussed in Section 7.3 will be documented as outlined in the specific SOPs cited. Field data will be managed according to SOP FO.2.

Field data will be input to RFEDs using a remote data entry module supplied by EG&G. Data will be entered on a 3.5-inch computer diskette and will be delivered to EG&G on a timely basis. A hard copy report will be generated from the module for contractor use. Procedures for data quality control, verification, entry into RFEDS, archiving and security will follow SOP FO.14.

A sample tracking spreadsheet will be maintained by the contractor for use in tracking sample collection and shipment. EG&G will supply the spreadsheet format and will stipulate timely reporting of information. These data will also be delivered to EG&G on 3.5-inch computer diskettes. Computer hardware and software requirements for contractors using government-supplied equipment will be supplied by EG&G. Computer and data security measures will also follow acceptable procedures outlined by EG&G.

7.6 FIELD QC PROCEDURES

Sample quality will be controlled by following the prescribed SOPs or accepted methods for sample collection, sample shipment, equipment use, equipment decontamination, and equipment calibration as discussed previously in the FSP. These procedures provide the best methods for collection of representative samples. In addition, three types of field quality control (QC) samples will be collected: sample duplicates, field preservation blanks, and equipment rinsate blanks. An additional QC sample, a trip blank, will be prepared when needed by the laboratory performing the analyses.

The analytical results obtained for these samples will be used by the ER project manager to assess the quality of the field sampling effort. The types of field QC samples to be collected and their application are discussed below. The frequency with which QC samples will be collected and analyzed is provided in Table 7.4.

Duplicate samples will be collected by the sampling team for use as a relative measure of the precision of the sample collection process. These samples will be collected at the same time, using the same procedures and equipment, and in the same types of containers as required for the samples. They will also be preserved in the same manner and submitted for the same analyses as required for the samples. Duplicate samples will only be collected during ground water sampling.

Field preservation blanks of distilled water, preserved according to the preservation requirements (Section 7.4.3), will be prepared by the sampling team and will be used to provide an indication of any contamination introduced during field sample preparation. As indicated in Table 7.4, these QC samples are applicable only to samples requiring chemical preservation.

Equipment rinsate blanks will be collected from final decontamination rinsate to evaluate the success of the field sampling team's decontamination efforts on non-dedicated sampling equipment. Equipment blanks are obtained by rinsing cleaned equipment with distilled water prior to sample collection. The rinsate is collected and placed in the appropriate sample containers. Equipment rinsate blanks are applicable to all analyses for water and soil samples, as indicated in Table 7.4.

Trip blanks consisting of distilled water will be prepared by the laboratory technician and will accompany each shipment of samples for volatile organic analysis. Trip blanks will be stored with the group of samples with which they are associated. Analysis of the trip blank will indicate migration of volatile organics or any problems associated with sample shipment, handling, or storage. Information from the trip blanks will be used in conjunction with air monitoring data and other information to assess the influence of ongoing waste operations on the quality of data collected.

Procedures for monitoring field QC are provided in the sitewide QAPP. The collection of QC samples will be documented on the proper soil or water sample collection logs per SOPs GT.2, GT.8, and GW.6.

7.7 AIR MONITORING SURVEILLANCE ACTIVITIES

Air monitoring will be performed during field activities to ensure that quality data are obtained during sampling and that all sampling activities comply with the Interim Plan for Prevention of Contaminant Dispersion (IPPCD) (EG&G, 1991). Air quality monitoring will be performed in accordance with SOPs presently being developed by EG&G.

Air quality monitoring requirements for activities such as borehole drilling where there is a significant potential for producing appreciable quantities of suspended particulates include the following:

- Site perimeter and community Radiological Ambient Air Monitoring Program (RAAMP) data for radiological parameters will be available.
- Local monitoring of Respirable Suspended Particulates (RSP) at individual activity work sites shall be conducted using a TSI "Piezobalance" Model 3500 Respirable Aerosol Mass Monitor, a real-time instrument. Local RSP measurements will be used to guide the project Manager's evaluation of the potential hazards associated with activity-related emissions. The threshold RSP concentration for curtailing intrusive activities will be 6.0 milligrams/cubic meter (mg/m^3).
- Additional worker health and safety monitoring as required by the Site-Specific Health and Safety Plan (SSH&SP).

Table 7.1: Phase I Soil, Sediment, and Water Page 1 of 7
Sampling Parameters and Detection Limits/Quantitation Limits

Target Analyte List - Metals	Detection Limits*	
	Water (µg/l)	Soil/Sediment (mg/kg)
Aluminum	200	40
Antimony	60	12
Arsenic	10	2
Barium	200	40
Beryllium	5	1.0
Cadmium	5	1.0
Calcium	5000	2000
Cesium	1000	200
Chromium	10	2.0
Cobalt	50	10
Copper	25	5.0
Cyanide	10	10
Iron	100	20
Lead	5	1.0
Lithium	100	20
Magnesium	5000	2000
Manganese	15	3.0
Mercury	0.2	0.2
Molybdenum	200	40
Nickel	40	8.0
Potassium	5000	2000
Selenium	5	1.0
Silver	10	2.0
Sodium	5000	2000
Strontium	200	40

Table 7.1: Phase I Soil, Sediment, and Water Page 2 of 7
Sampling Parameters and Detection Limits/Quantitation Limits

Thallium	10	2.0
Tin	200	40
Vanadium	50	10.0
Zinc	20	4.0

Quantitation Limits*

Target Compounds List - Volatiles

	Water (µg/l)	Soil/Sediment (µg/kg)
Chloromethane	10	10
Bromomethane	10	10
Vinyl Chloride	10**	10
Chloroethane	10	10
Methylene Chloride	5	5
Acetone	10	10
Carbon Disulfide	5	5
1,1-Dichloroethene	5	5
1,1-Dichloroethane	5	5
trans 1,2-Dichloroethene	5	5
Chloroform	5	5
1,2-Dichloroethane	5	5
2-Butanone	10	10
1,1,1-Trichloroethane	5	5
Carbon Tetrachloride	5	5
Vinyl Acetate	10	10
Bromodichloromethane	5	5
1,1,2,2,-Tetrachloroethane	5	5
1,2-Dichloropropane	5	5

trans-1,3-Dichloropropene	5	5
Trichloroethene	5	5
Dibromochloromethane	5	5
1,1,2-Trichloroethane	5	5
Benzene	5	5
cis-1,3-Dichloropropene	5	5
Bromoform	5	5
2-Hexanone	10	10
4-Methyl-2-pentanone	10	10
Tetrachloroethene	5	5
Toluene	5	5
Chlorobenzene	5	5
Ethyl Benzene	5	5
Styrene	5	5
Total Xylenes	5	5

Quantitation Limits*

Semivolatiles

	Water $\mu\text{g}/\ell$	Soil/Sediment $\mu\text{g}/\text{Kg}$
Phenol	10**	330
bis(2-Chloroethyl)ether	10**	330
2-Chlorophenol	10**	330
1,3-Dichlorobenzene	10	330
1,4-Dichlorobenzene	10	330
Benzyl alcohol	10	330
1,2-Dichlorobenzene	10	330
2-Methylphenol	10	330
bis(2-Chloroisopropyl)ether	10	330
4-Methylphenol	10	330
N-Nitroso-di-n-propylamine	10	330

Hexachloroethane	10	330
Nitrobenzene	10**	330
Isophorone	10	330
2-Nitrophenol	10	330
2,4-Dimethylphenol	10	330
Benzoic acid	50	1600
bis(2-Chloroethoxy)methane	10	330
2,4-Dichlorophenol	10	330
1,2,4-Trichlorobenzene	10	330
Naphthalene	10	330
4-Chloroaniline	10	330
Hexachlorobutadiene	10	330
4-Chloro-3-methylphenol (para-chloro-meta-cresol)	10	330
2-Methylnaphthalene	10	330
Hexachlorocyclopentadiene	10	330
2,4,6-Trichlorophenol	10	330
2,4,5-Trichlorophenol	50	1600
2-Chloronaphthalene	10	330
2-Nitroaniline	50	1600
Dimethylphthalate	10	330
Acenaphthylene	10	330
2,6-Dinitrotoluene	10	330
3-Nitroaniline	50	1600
Acenaphthene	10	330
2,4-Dinitrophenol	50	1600
4-Nitrophenol	50	1600
Dibenzofuran	10	330
2,4-Dinitrotoluene	10	330

Diethylphthalate	10	330
4-Chlorophenyl-phenyl ether	10	330
Fluorene	10	330
4-Nitroaniline	50	1600
4,6-Dinitro-2-methylphenol	50	1600
N-nitrosodiphenylamine	10	330
4,-Bromophenyl-phenylether	10	330
Hexachlorobenzene	10**	330
Pentachlorophenol	50	1600
Phenanthrene	10	330
Anthracene	10	330
Di-n-butylphthalate	10	330
Fluoranthene	10	330
Pyrene	10	330
Butylbenzylphthalate	10	330
3,3'-Dichlorobenzidine	20**	660
Benzo(a)anthracene	10	330
Chrysene	10	330
bis(2-Ethylhexyl)phthalate	10	330
Di-n-octylphthalate	10	330
Benzo(b)fluoranthene	10	330
Benzo(k)fluoranthene	10	330
Benzo(a)pyrene	10	330
Indeno(1,2,3-cd)pyrene	10	330
Dibenz(a,h)anthracene	10	330
Benzo(g,h,i)perylene	10	330

Quantitation Limits*

Target Compound List - Pesticides/PCBs

	Water (µg/l)	Soil/Sediment (µg/kg)
alpha-BCH	0.05	8.0
beta-BCH	0.05	8.0
delta-BCH	0.05	8.0
gamma-BCH (Lindane)	0.05	8.0
Heptachlor	0.05**	8.0
Aldrin	0.05**	8.0
Heptachlor epoxide	0.05**	8.0
Endosulfan I	0.05	8.0
Dieldrin	0.10	16.0
4,4'-DDD	0.10	16.0
Endrin	0.10	16.0
Endosulfan II	0.10	16.0
4,4'-DDE	0.10	16.0
Endosulfan sulfate	0.10	16.0
4,4'-DDT	0.10	16.0
Methoxychlor	0.5	80.0
Endrin ketone	0.10	16.0
alpha-Chlordane	0.5**	80.0
gamma-Chlordane	0.5**	80.0
Toxaphene	1.0	160.0
Arochlor-1016	0.5**	80.0
Arochlor-1221	0.5**	80.0
Arochlor-1232	0.5**	80.0
Arochlor-1242	0.5**	80.0
Arochlor-1248	0.5**	80.0
Arochlor-1254	1.0**	160.0
Arochlor-1260	1.0**	160.0

Required Detection Limits*

Radionuclides	<u>Water (pCi/l)</u>	<u>Soil/Sediment (pCi/g)</u>
Gross Alpha	2	4 dry
Gross Beta	4	10 dry
Uranium 233+234, 235, and 238 (each species)	0.6	0.3 dry
Americium 241	0.01	0.02 dry
Plutonium 239+240	0.01	0.03 dry
Tritium	400	400 (pCi/ml)
Cesium 137	1	0.1 dry
Strontium 89+90	1	1 dry

Detection Limits*

Parameters Exclusively for Groundwater
SamplesWater (mg/l)**Anions**

	10
Carbonate	10
Bicarbonate	5
Chloride	5
Sulfate	5
Nitrate as N	

Field Parameters

pH	0.1 pH unit
Specific Conductance	1
Temperature	
Dissolved Oxygen	0.5
Barometric Pressure	

Indicators

Total Dissolved Solids

5

*Detection and quantitation limits are highly matrix dependent. The limits listed here are the minimum achievable under ideal conditions. Actual limits may be higher.

**The laboratory Practical Quantification Limits (PQLs) for these analytes exceed ARARs.

**Table 7.2: Sample Containers, Sample Preservation,
and Sample Holding Times for Water Samples**

Parameter	Container	Preservative	Holding Time
<u>Liquid - Low to Medium Concentration Samples</u>			
Organic Compounds:			
Purgeable Organics (VOCs)	2 x 40-ml VOA vials with teflon-lined septum lids	Cool, 4°C ^a with HCL to pH<2	7 days 14 days
Extractable Organics (BNAs), Pesticides and PCBs	1 x 4-l amber ^b glass bottle	Cool, 4°C	7 days until extraction, 40 days after extraction
Inorganic Compounds:			
Metals (TAL)	1 x 1-l polyethylene bottle	Nitric acid pH<2; Cool, 4°C	180 days ^c
Cyanide	1 x 1-l polyethylene bottle	Sodium hydroxide ^d pH>12; Cool, 4°C	14 days
Anions	1 x 1-l polyethylene bottle	Cool, 4°C	14 days
Sulfide	1 x 1-l polyethylene bottle	1 ml-zinc acetate sodium hydroxide to pH>9; Cool, 4°C	7 days
Nitrate	1 x 1-l polyethylene bottle	Cool, 4°C	48 hours
Total Dissolved Solids (TDS)	1 x 1-l polyethylene bottle	Cool, 4°C	48 hours
Radionuclides	1 x 1-l polyethylene bottle	Nitric acid pH<2;	180 days

^aAdd 0.008% sodium thiosulfate (Na₂S₂O₃) in the presence of residual chlorine.

^bContainer requirement is for any or all of the parameters given.

^cHolding time for mercury is 28 days.

^dUse ascorbic acid only if the sample contains residual chlorine. Test a drip of sample with potassium iodine-starch test paper; a blue color indicates need for treatment. Add ascorbic acid, a few crystals at a time, until a drop of sample produces no color on the indicator paper. Then add an additional 0.6g of ascorbic acid for each liter of sample volume.

**Table 7.3: Sample Containers, Sample Preservation,
and Sample Holding Times for Soil Samples**

Parameter	Container	Preservative	Holding Time
<u>Soil or Sediment Samples - Low to Medium Concentration</u>			
Organic Compounds:			
Purgeable Organics (VOCs)	1 x 4-oz wide-mouth teflon-lined glass vials	Cool, 4°C	7 days 14 days
Extractable Organics (BNAs), Pesticides and PCBs	1 x 8-oz wide-mouth teflon-lined glass vials	Cool, 4°C	7 days until extraction, 40 days after extraction
Inorganic Compounds:			
Metals (TAL)	1 x 8-oz wide-mouth glass jar	Cool, 4°C	180 days ¹
Cyanide	1 x 8-oz wide-mouth glass jar	Cool, 4°C	14 days
Sulfide	1 x 8-oz wide-mouth glass jar	Cool, 4°C	28 days
Nitrate	1 x 8-oz wide-mouth glass jar	Cool, 4°C	48 hours
Radionuclides	1 x 1-ℓ wide-mouth glass jar	None	45 days

¹Holding time for mercury is 28 days.

Table 7.4: Field QC Sample Frequency

Sample Type	Type of Analysis	Media	
		Solids	Liquids
Duplicates	Organics	1/10	1/10
	Inorganics	1/10	1/10
	Radionuclides	1/10	1/10
Field Preservation Blanks	Organics	NA	NA
	Inorganics	NA	1/20
	Radionuclides	NA	1/20
Equipment Blanks	Organics	1/20	1/20
	Inorganics	1/20	1/20
	Radionuclides	1/20	1/20
Trip Blanks	Organics	NR	1/20
	Inorganics	NR	NR
	Radionuclides	NR	NR

NA = Not Applicable

NR = Not Required

1/10 = one QC sample per ten samples collected

8.0 HUMAN HEALTH RISK ASSESSMENT PLAN

8.1 OVERVIEW

Section 300.430(d) of the National Contingency Plan states that as part of the remedial investigation, a Baseline Risk Assessment is to be conducted to determine whether contaminants of concern identified at the site pose a current or potential future risk to human health (Human Health Risk Assessment) and the environment (Environmental Evaluation) in the absence of remedial action. This section describes the Human Health Risk Assessment components which include:

- Data Collection/Evaluation
- Exposure assessment
- Toxicity assessment
- Risk characterization.

The Environmental Evaluation is described in Section 9.0 of this Work Plan.

Figure 8-1 illustrates the basic Human Health Risk Assessment process and components. The Human Health Risk Assessment objective is to identify and assess potential human health risks resulting from exposure to site contaminants present in various environmental media. Several objectives will be accomplished under the Human Health Risk Assessment task, including identification and characterization of the following:

- Toxicity and levels of hazardous substances present in relevant media (e.g., air, groundwater, soil, surface water, sediment, and biota)
- Environmental fate and transport mechanisms within specific environmental media, and inter-media fate and transport where appropriate
- Potential human and environmental receptors
- Potential exposure routes and extent of actual or expected exposure
- Extent of expected impact or threat, and the likelihood of such impact or threat occurring (e.g., risk characterization)
- Level(s) of uncertainty associated with the above.

Human Health Risk Assessment results will be used to determine if remedial actions are warranted at OU4 and, if so, the associated cleanup levels necessary to protect human health.

A number of EPA guidance documents will be used to provide direction for developing the Human Health Risk Assessment. The documents listed in Table 8.1 constitute the most recent EPA guidance in public health risk assessment. It must be emphasized that EPA manuals are guidelines only, and that EPA states that considerable professional judgement must be used in their application. The focus of the risk assessment for OU4 will be to produce a realistic analysis of exposure and health risk.

To accomplish the characterization of the magnitude of the exposure/dose assessment for radionuclides, a number of documents will be referenced, including but not limited to DOE Order 5400.5, Federal Guidance Report No. 10 (U.S. EPA, 1984), and Federal Guidance Report No. 11 (U.S. EPA, 1988e). The dose calculations shall provide an estimate of the committed effective dose equivalent to an individual in the population which can then be compared to lifetime risk from radiation exposure. Estimates of lifetime risk of cancer to exposed individuals resulting from radiological and chemical risk assessments will be tabulated separately in the final human health risk assessment. In addition to available national EPA guidance, supplemental Region VIII risk assessment guidance will be used if applicable.

The following sections of the Human Health Risk Assessment Plan will be applicable to both Phase I and Phase II tasks undertaken at OU4. Although the Phase I Work Plan objectives are limited to characterization of the source term and soil contamination, this limited characterization must meet the applicable data needs and data usability described in this section. Existing available information on ground water, surface water, and air quality will be incorporated to the extent practicable. This information can then be applied to each component of the risk assessment process, and a partial Human Health Risk Assessment will be developed.

8.2 DATA COLLECTION/EVALUATION

This section outlines the process that will be used to identify source-related contaminants present at OU4 at concentrations that could be of concern to human health. This process includes a summary of historical and RFI/RI related data collected at OU4, an evaluation of historical and RFI/RI data relevant to performing the Human Health Risk Assessment, and use of this information to identify contaminants of concern (COCs). COCs include chemicals and other constituents, such as metals or radionuclides, that are identified at the unit and evaluated in the Human Health Risk Assessment.

8.2.1 Data Collection

The first step in the process is a summary of all data available for use in the Human Health Risk Assessment. This step identifies the historical data relevant to performing the Human Health Risk Assessment, assembles Phase I RFI/RI data as they become available, and establishes data formats to facilitate data evaluation. Data attributes important to this step include the following information:

- Site description
- Sample design with sampling locations
- Analytical method and detection limit
- Results for each sample, including qualifiers
- Sample quantitative limits and/or detection limits for non-detects
- Field conditions.

8.2.2 Data Evaluation

Historical and Phase I RFI/RI data will be further evaluated in part by EPA's guidelines issued in Guidance for Data Useability in Risk Assessment (EPA, 1990). Internal EG&G QA/QC guidelines will also be used to evaluate the usability of historical data available. EPA has identified the following data useability criteria:

- Assess data documentation for completeness
- Assess data sources for appropriateness and completeness
- Assess analytical methods and detection limits for appropriateness
- Assess data validation review
- Assess sampling data quality indicators (completeness, comparability, representativeness, precision, and accuracy)
- Assess analytical data quality indicators (such as spike recoveries, duplicates, and blanks) for completeness, comparability, representativeness, precision, and accuracy.

Following completion of the Phase I RFI/RI data collection, analysis, and validation, new data will be evaluated to determine if they support historical trends. Where new data and historical data appear compatible, the historical data will undergo re-evaluation to identify those that could be used quantitatively in conjunction with new data.

Based on the outcome of this evaluation, the data set containing historical and RFI/RI data that can be used to support a quantitative Human Health Risk Assessment will be identified. Part of this evaluation will include the most appropriate summary process and format. This will involve

identifying statistical summary techniques that consider spatial and temporal data distributions, determining if arithmetic or geometric means are appropriate, and determining the appropriate method for dealing with non-detected values and qualified data. The data summary will include:

- The frequency of detection (number of positive detects/number of analyses) for each compound and sample location
- The minimum- and maximum-reported concentrations for each compound at each sample location.

Tentatively identified compounds (TICs) reported in the RFI/RI data will be evaluated relative to their usefulness in the Human Health Risk Assessment. If only a few TICs are reported relative to other contaminants, or if they are unrelated to the RFP, they will be excluded from the Human Health Risk Assessment. If numerous TICs are reported and they appear related to the RFP, they will be carried through the Human Health Risk Assessment only to the extent that they aid in characterizing human health risk as needed for site decisions. It is unlikely that risks resulting from exposure to TICs cannot be characterized at this time because of the absence of specific contaminant identity and available toxicological information.

8.2.3 Hazard Identification

The objective of the hazard identification is to identify RFP-related contaminants of concern (COCs) present at OU4 in concentrations high enough that may be of concern relative to human health considerations. Criteria for performing the hazard identification include but may not be limited to:

- Frequency of detection
- Environmental media concentrations exceed background concentrations
- Toxicity, mobility, and persistence.

From the list of valid data suitable for use in the risk assessment, potential site-specific COCs may be identified based on the following considerations:

- The chemical is identified as a site-specific, waste activity related compound released from an identified source at the IHSS.
- The concentration of the chemical exceeds the chemical-specific ARARs.
- The chemical is detected at a frequency greater than 5 percent of the time in an individual media (e.g., surface soil, subsurface soil, alluvial ground water, etc.).
- The concentration of the chemical exceeds the 95 percent Upper Tolerance Limit of the background concentration estimate.

- The chemical is a potential carcinogenic compound classified as: Group A - sufficient evidence of carcinogenicity in humans, Group B1 - limited evidence of carcinogenicity in humans, and Group B2 - sufficient evidence in animals with inadequate evidence in humans.
- The occurrence of a non-carcinogenic compound in media at a concentration 0.1 times the derived media concentration (DMC). (The DMC equals the exposure dose divided by the reference dose.)
- The chemical's inter-media transport, persistence, and biometabolic characteristics.
- The chemical's role as a nutrient.

Depending on the number of site-related contaminants identified, one of two things will happen under both current and potential future conditions:

1. If only a few site-related contaminants are identified, all of them will be carried through the risk assessment. The contaminants responsible for dominant risks at the site, as well as those contributing lower risk, will be identified.
2. If a large number of site-related contaminants are identified, contaminants of concern may be selected and carried through the risk assessment to characterize only those expected to contribute the highest risk. contaminants of concern will then be selected in accordance with the Risk Assessment Guidance for Superfund (U.S. EPA, 1989c) that requires the following:
 - Evaluating site historical information
 - Evaluating contaminant concentrations and toxicities
 - Examining contaminant mobility, persistence, and bioaccumulation
 - Identifying release mechanisms
 - Identifying special exposure routes
 - Evaluating contaminant treatability (retain those more difficult to treat than others)
 - Assessing availability of contaminant ARARs
 - Grouping chemicals by class according to structure-activity relationships or other similarities
 - Evaluating frequency of detection
 - Estimating intake
 - Identifying essential nutrients

- Using a concentration-toxicity screen to identify those contaminants that are expected to contribute the most to overall risks.

To judge the degree and extent of risk to public health and the environment (including plants, animals, and ecosystems), the projected concentrations of COCs at exposure points will be compared with ARARs, as stated in Section 3.0 of this Work Plan. Because ARARs do not exist for certain media (such as soils), nor are all ARARs necessarily health based, this comparison is not sufficient in itself to satisfy the requirements of the risk assessment process. Moreover, receptors may be exposed to contaminants in more than one medium so that their total doses might exceed risk reference doses (RfDs) and/or might result in an excess cancer risk greater than an acceptable target risk, as defined by EPA (e.g., 10^{-6} to 10^{-4}). Nevertheless, the comparison with standards and criteria is useful in defining the exceedence of institutional requirements. Aside from the ARARs discussed in Section 3.0, the following criteria will be examined:

- Drinking-water health advisories
- Ambient water quality criteria for protection of human health
- Center for Disease Control and Agency for Toxic Substances and Disease Registry soil advisories
- National Ambient Air Quality Standards.

Potential COCs will be evaluated in terms of all considerations in an iterative process. Thus, a chemical may be eliminated as a COC on the basis of one criterion, but it may subsequently be identified as a COC on the basis of another criterion (and vice-versa). Adequate documentation will be prepared to justify including or excluding specific contaminants.

8.2.4 Uncertainty in Data Collection Evaluation

The assessment of the data collection process listed above involves the evaluation of five indicators: completeness, comparability, representativeness, precision, and accuracy. Uncertainty within each of these parameters will influence the selection of COCs, affect the estimates of average and maximum concentration of the chemical, and ultimately influence the risk characterization results. A qualitative identification of the key site variables such as sampling location, sampling frequency, use of historical data, and selection of COCs will be performed for this Data Collection/Evaluation Section.

8.3 EXPOSURE ASSESSMENT

The exposure assessment objective is to determine how exposures to site contaminants could occur, and to estimate the extent of exposure if it occurs. The exposure assessment includes several tasks:

- Characterize the exposure setting relative to contaminant fate and transport and potentially exposed populations.
- Identify exposure pathways based on chemical source and release, exposure point, and exposure route.
- Identify uncertainties associated with the exposure assessment that impact the risk characterization.

Exposure is defined as the contact of an organism with a contaminant or physical agent. The magnitude of exposure is determined by measuring or estimating the amount of a contaminant available at the exchange boundaries (i.e., lungs, intestines, and skin). When contaminants migrate from the site to an exposure point (a location where receptors can come into contact with contaminants), or when a receptor directly contacts the contaminated media, exposure can occur. The radionuclides present at this OU do produce an external exposure hazard albeit a minor one. Nevertheless, this external exposure route will be assessed and used in the risk characterization.

8.3.1 Conceptual Site Model

The site conceptual model for OU4 (Figures 2-30 and 2-31) will be used to evaluate primary and secondary contaminant sources and releases, and potential receptors and associated exposures. The model helps to characterize the exposure setting relative to contaminant fate and transport mechanisms through exposed receptors. The conceptual site model for OU4 may be revised on RFI/RI data collected for the OU4 to incorporate new information. Although not explicitly described by the OU4 conceptual site model, residential and occupational exposure pathways through ingestion, inhalation, or dermal contact with site-related contaminants will be considered for evaluation in the risk characterization if the revised conceptual model suggests they may be complete exposure pathways. A completed exposure pathway consists of all five of the elements listed below:

1. Source of contaminant
2. Mechanism of chemical release to the environment
3. Environmental transport medium (e.g., air, ground water) for the released constituent
4. Point of potential contact of human or biota with the affected medium (the exposure point)

5. Exposure route (e.g., inhalation of contaminated dust) at the exposure point.

If any of these five elements is missing from a potential pathway, exposure cannot occur and thus the pathway can be eliminated from the risk assessment process. The conceptual model contains all potential exposure pathways, and part of the goal of the RFI/RI Work Plan is to determine if a completed exposure pathway exists.

8.3.2 Contaminant Fate and Transport

The conceptual site model helps identify potential contaminant fate and transport mechanisms. These could include soil contaminants leaching to ground water, soil entrainment and downwind deposition, or surface runoff that transports surface soil downslope. Contaminant-specific characteristics affect fate and transport. Chemical specific factors affecting the probability a contaminant will migrate include, but are not limited to:

- Solubility
- Partition coefficient
- Vapor pressure
- Henry's Law constant
- Bioconcentration factor.

The evaluation of these chemical specific factors will help determine if contaminants can migrate from their sources to potential receptors, not only those identified under current use scenarios but those identified under potential future exposure scenarios as well.

8.3.3 Exposure Pathways

By using the conceptual site model and information on contaminant fate and transport, exposure pathways can be identified. The Human Health Risk Assessment will consider only complete exposure pathways (or pathways that could be complete under potential future situations), those for which data support the presence of a source, release mechanism, transport mechanism, exposure route, and affected receptor. Complete exposure pathways include the receptors and exposure route (ingestion, inhalation, and dermal).

8.3.4 Potential Receptors

The exposure scenarios that will be developed in the Human Health Risk Assessment may include exposure of on-site workers, exposure of potential future receptors to contaminated media within OU4, and exposure of off-site receptors to potentially contaminated ground water, surface water,

and airborne soil particulates. The exact exposure scenarios to be considered will be selected according to an assessment of future use (e.g., residential, recreational, restricted access) of the site that may be made prior to completion of the Human Health Risk Assessment.

8.3.5 Exposure Point Concentrations

By using the data set identified as part of Subsection 8.2.2, and the results of contaminant fate and transport modeling, exposure point concentrations of COCs will be estimated on the basis of analytical results of the sampling program described in Section 7.0 of this Work Plan and available relevant historical data. Some data will be collected at the point of exposure. Other data collected at the source may be used in conjunction with a transport model to estimate expected concentration at some exposure point. Because modeling may add uncertainty, the Work Plan emphasizes collecting data at exposure points where possible (even though these data provide only a snapshot of conditions in time and space).

Release and transport of contaminants in environmental media may be modeled using basic analytical and/or numerical models recommended by EPA or the best model available, as determined by a model performance evaluation. The models will be calibrated to improve performance using site-specific parameters.

Model outputs will be characterized by estimating variance through an uncertainty analysis to the extent required by the overall risk uncertainty analysis. Reasonable efforts will be made to minimize the variance of model output. Other major contributors to the overall risk assessment uncertainty include exposure factors used in the estimation of intake and the toxicity parameters (reference dose and cancer slope factors) used to evaluate the effect of an acquired dose.

Exposure point concentrations will be expressed as reasonable maximum exposure (RME) concentrations and average concentrations. RME concentrations are represented by the 95th percent confidence limit on the average or the maximum-reported concentration, whichever is lower. Depending on the quantity of data and their appropriateness for grouping, data distribution will be used to determine the appropriateness of using geometric or arithmetic means to estimate the RME concentrations.

When feasible, a goodness-of-fit analysis will be conducted to correctly identify the distribution of the data and the most appropriate measure of central tendency. The reasonable maximum concentra-

tion will be the upper 95th percent confidence limit on the appropriate mean or maximum likelihood estimate. In calculating the media concentrations, censored data (data sets with missing values, non-detects, etc.) will be treated by appropriate methods such as those described in *Statistical Methods for Environmental Pollution Monitoring* (Gilbert, 1987).

8.3.6 Contaminant Intake Estimation

In general, chemical intakes will be estimated using available, region-specific exposure parameters. Deviation from standard parameters will be documented and submitted to the regional EPA office for approval prior to preparation of the risk assessment.

Contaminant exposure (or intake) is normalized for time and body weight and is expressed as milligrams of contaminant per kilogram of body weight per day (mg/kg/day). Radionuclide intake is based on total activity and is expressed as picoCuries of radionuclide (pCi). Six basic factors are used to estimate intake: exposure frequency, exposure duration, contact rate, chemical concentrations, body weight, and averaging time. These factors are based on the types of exposure (e.g., residential or occupational, ingestion, or inhalation).

The RME and average exposure point concentrations are used in conjunction with receptor activity patterns to estimate contaminant intake for each exposure route as appropriate. EPA requires using 95th percentile rates, 90th or 95th percentile values for exposure duration, and average values for parameters such as body weight. For example, a residential land use scenario describes an adult, weighing 70 kilograms, who works at home and consumes 2 liters of water and breathes 20 cubic meters (m³) of air per day. The individual stays at home 350 days per year and lives in the same residence for 30 years. Different parameters are used for children, adult workers, and recreational exposures based on information provided by EPA in the *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual Supplemental Guidance, "Standard Default Exposure Factors" Interim Final*, March 25, 1991 (EPA, 1989b). Also, the averaging time for carcinogens and non-carcinogens differ.

Other standard intake rates established by EPA that will be used, if appropriate, include the following:

- Soil ingestion rates for children ages 1 through 6
- Soil ingestion rates for all others (workers and residents more than 6 years of age)
- Inhalation rates based on activity levels.

Contaminant rates can also be estimated for dermal exposures. Of the three routes of exposure (ingestion, inhalation, and dermal), the greatest uncertainty is associated with dermal exposures. Part of this uncertainty results from the lack of chemical-specific permeability constants. The Human Health Risk Assessment will calculate the estimated contaminant intake through dermal exposures and compare the intake values to those calculated for ingestion as the basis for demonstrating the significance of the dermal route relative to other routes of exposure.

Human intake of COCs will be estimated using reasonable estimates of exposure parameters. EPA guidance, site-specific factors, and professional judgement will be applied in establishing exposure assumptions. Using reasonable values allows estimation of risks associated with the assumed exposure conditions without underestimating actual risk. The estimate of intake is the "intake factor," which may then be mathematically combined with the exposure point concentrations and the critical toxicity values to determine cancer risks and hazard indices.

Depending on the data collected and the refinement of the conceptual site model, nontraditional exposure routes that may be included in the Human Health Risk Assessment, include fish ingestion and exposures resulting from recreational uses of the reservoirs (contact with sediments, ingestion, and dermal contact with surface water) and the nearby open spaces (hiking, bicycling).

Other nontraditional exposure routes may be identified by using land use data for the OU4 area. These include exposure scenarios related to agricultural land uses and other recreational land uses within the OU4 area.

8.3.7 Uncertainty in the Exposure Assessment

The ability to construct exposure scenarios for a site depends on the amounts and kinds of environmental data collected for that purpose. Some uncertainty is inherent in environmental data collection. The numbers and kinds of uncertainties included in the exposure assessment directly impact the risk characterization; many professional judgements impact the identification and description of physical site attributes that affect exposure and activity patterns. One of the major areas of uncertainty in the exposure assessment is the prediction of human activities that lead to contact with environmental media and exposures to site-related contaminants. This section of the Human Health Risk Assessment will identify and describe how site attributes related to environmental sampling and analysis, fate and transport modeling, and exposure parameter estimation and assumptions about them affect uncertainty relative to assessing risk. The exposure assessment uncertainty analysis will

discuss the potential magnitude of over- or under-estimation, or both, provides an indication of the impact, by orders of magnitude, the uncertainty imparts on the estimation of risk.

The uncertainty analysis will identify and evaluate non-site-specific and site-specific factors that may produce uncertainty in the risk assessment, such as assumptions inherent to development of toxicological endpoints (potency factors, reference doses) and assumptions considered in the exposure assessment (model input variability, population dynamics). Statistical simulation techniques (such as Monte-Carlo) may be employed for contaminants for which quantitative evaluation is possible. The goal of this task will be to quantify, to the extent practicable, the uncertainty propagated through the risk assessment process. The uncertainty analysis will present the spectrum of potential risks under specified scenarios such that the risk management decision maker can obtain an understanding of the level of confidence associated with all estimates of potential human health risk.

8.4 TOXICITY ASSESSMENT

The objective of the toxicity assessment is to describe the contaminants considered in the Human Health Risk Assessment relative to their potential to cause harm. The toxicity assessment has two general steps. The first determines what adverse health impacts, if any, could result from exposure to a particular contaminant. These are typically classified as carcinogenic and non-carcinogenic health effects. The second step, dose-response evaluation, quantitatively examines the relationship between the level of exposure and the incidence of adverse health effects.

Toxicity depends on the dose or concentration of the substance (dose-response relationship). Toxicity values are a quantitative expression of the dose-response relationship for a contaminant and take the form of reference doses (RfD) and cancer slope factors, both of which are specific to exposure via different routes.

Two sources of toxicity values are currently available for chemicals and radionuclides. The primary source is the EPA's Integrated Risk Information System (IRIS) database. IRIS contains up-to-date health risk and regulatory information. IRIS contains only those RfDs and slope factors that have been verified by the U.S. EPA work groups and is considered by U.S. EPA to be the preferred source of toxicity information for chemicals.

Following IRIS, the most recently available Health Effects Assessment Summary Tables (HEAST), issued by the U.S. EPA's Office of Research and Development, will be consulted to identify interim RfDs and slope factors for radionuclides.

In addition to identifying appropriate toxicity values, this section of the Human Health Risk Assessment will provide brief toxicity profiles based on recent, published literature for each contaminant evaluated in the Human Health Risk Assessment. These profiles will describe the acute, chronic, and carcinogenic health effects associated with site-related contaminants identified in OU4. Acute and chronic exposure to site-related radionuclides will be discussed, but most of the information presented will deal with the carcinogenic hazard posed by the site-specific radionuclides.

8.4.1 Uncertainty In Toxicity Assessment

A summary of the uncertainty inherent in the toxicity values for the COCs shall be compiled and included in the Human Health Risk Assessment. This summary shall include the following information:

- Qualitative hazard findings
 - potential for human toxicity
- Derivation of toxicity values
 - human or animal data
 - duration of study
- Potential for synergistic or antagonistic interaction with other substances
- Calculation of lifetime cancer risks on the basis of less than lifetime exposures.

8.5 RISK CHARACTERIZATION

This section of the Human Health Risk Assessment presents the evaluation of potential risks to public health associated with exposure to contaminants at the OU4 site. Potential carcinogenic and non-carcinogenic risks associated with complete exposure pathways will be estimated. Risk characterization involves integrating exposure assumptions and toxicity information to quantitatively estimate the risk of adverse health effects. Risk characterization will be performed in accordance with EPA guidance (U.S. EPA, 1989b).

Non-cancer risk will be assessed by comparing the estimated daily intake of a contaminant to its RfD. This comparison measures the potential for non-carcinogenic health effects given the chemical intake factors used to estimate exposure. To assess the potential for non-cancer effects posed by multiple chemicals, EPA's hazard index approach will be used. This method assumes dose additivity. Hazard quotients (individual chemical intake divided by the chemical RfD) are summed to provide a hazard index, and if the index exceeds one, a potential for health risk is suggested. If a hazard index exceeds one, where possible, chemicals may be segregated by similar effect or target organ to determine the potential health risks. Separate hazard indexes may be derived for each effect if sufficient information or target organ specificity is available.

The potential for carcinogenic effects will be estimated by calculating excess lifetime cancer risks from the lifetime average exposure and cancer slope factor. These will be upper-bound estimates because methods used to estimate slope factors are regarded as upper bounds on potential cancer risks rather than accurate representations of true cancer risk.

Both non-cancer and cancer risks will be estimated by using RME and average contaminant intake values combined with exposure assumptions. This allows risk ranges to be considered rather than a single value and more closely considers the uncertainty associated with the estimates. In addition, risks may be added across exposure routes to assess the potential for additive effects.

Not all contaminants identified at OU4 will have toxicity values, thereby limiting the ability to develop quantitative estimates of risk. Where adequate toxicity values cannot be identified, potential risks associated with exposure to those constituents will be dealt with qualitatively.

8.5.1 Uncertainties in the Risk Characterization

The numbers and kinds of uncertainties identified in the Human Health Risk Assessment directly impact the interpretation of estimated risks developed in this section. Quantitative risk estimates derived in risk assessments are conditional estimates that include numerous assumptions about exposures and toxicity. Uncertainty is introduced from a variety of sources, including, but not limited, to the following sources:

- Sampling and analysis
- Exposure estimation
- Toxicological data.

As stated in the RAG (U.S. EPA, 1989c), a highly quantitative statistical uncertainty analysis is usually not practical or necessary for site risk assessments. As in all environmental risk assessments, it is already known that the uncertainty about the numerical results is large. Consequently, it is more important to identify the key site related variables and assumptions that contribute most to the uncertainty than to precisely quantify the degree of uncertainty in the risk assessment.

At a minimum, uncertainty will be described qualitatively in terms of under-or over-estimation of risk, or both. If possible, uncertainty may be described quantitatively using sensitivity analyses or other numerical models.

TABLE 8.1

**EPA GUIDANCE DOCUMENTS WHICH MAY BE USED
IN THE RISK ASSESSMENT TASK**

EPA's Integrated Risk Information System (IRIS) — Office of Research and Development (continuously updated). Agency's primary source of chemical-specific toxicity and risk assessment information. Includes narrative discussion of toxicity database quality and explains derivation of Reference Doses, cancer potency factors, and other key dose response parameters. IRIS presents information that updates data originally presented in Exhibits A-4 and A-6 of the SPHEM (see below). Further information: IRIS Users Support, 513-569-7254 (U.S. EPA, 1986b).

Health Effects Assessment Summary Tables (HEAST) — Office of Research and Development/Office of Emergency and Remedial Response (updated quarterly). Because the IRIS chemical universe (while growing) is currently incomplete, the HEAST has been produced to serve as a "pointer" system to identify current literature and toxicity information on important non-IRIS chemicals. While HEAST data in some cases may be "Agency-verified," the information is considered valuable for Superfund risk assessment purposes. Available from Superfund docket, 202-382-3046 (U.S. EPA, updated quarterly).

Risk Assessment Guidance for Superfund, Human Health Evaluation Manual Part A, Interim Final — Office of Emergency and Remedial Response. This volume provides updated risk assessment procedures and policies, specific equations and variable values for estimating exposure, and a hierarchy of toxicity data sources. There is an expanded chapter on risk characterization to help summarize information for the decision makers and detailed descriptions of uncertainties in risk assessment (U.S. EPA, 1989b).

OSWER Directive on Soil Ingestion Rates — Office of Solid Waste and Emergency Response (January 1989), OSWER Directive No. 9850.4. Recommends soil investigation rates for use in risk assessment when site-specific information is not available. Available from Darlene Williams, 202-475-9810 (U.S. EPA, 1989b).

Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference — Office of Solid Waste and Emergency Response EPA 600-3/89/013. This report is a field and laboratory reference document that provides guidance on designing, implementing, and interpreting ecological assessments of hazardous waste sites. It includes sections on ecological endpoints, field sampling design, quality assurance, aquatic and terrestrial toxicity and field survey methods, recommended biomarkers, and data analysis (U.S. EPA, 1989d).

Risk Assessment Guidance for Superfund — Environmental Evaluation Manual, Interim Final (RAGS-EEM) — Office of Emergency and Remedial Response (March 1989), EPA/540/1-89/001A. Provides program guidance to help remedial project managers and on-scene coordinators manage ecological assessment at Superfund sites (U.S. EPA, 1989c).

Exposure Factors Handbook — Office of Research and Development (March 1989), EPA/600/8-89/043. Provides statistical data on the various factors used in assessing exposure; recommends specific default values to be used when site-specific data are not available for certain exposure scenarios. Further information: Exposure Methods Branch, 202-382-5988 (U.S. EPA, 1989f).

TABLE 8.1 (continued)

**EPA GUIDANCE DOCUMENTS WHICH MAY BE USED
IN THE RISK ASSESSMENT TASK**

Superfund Public Health Evaluation Manual (SPHEM) — Office of Emergency and Remedial Response (U.S. EPA, 1986a), EPA/540/1-86/060. Describes sources of information useful in conducting risk assessments. Currently under revision.*

Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA — Office of Emergency and Remedial Response EPA/540/8-89/004. This guidance document is a revision of the U.S. EPA's 1985 guidance. It describes general procedures for conducting an RI/FS (U.S. EPA, 1988a).

Superfund Exposure Assessment Manual (SEAM) — Office of Emergency and Remedial Response (April 1988), EPA/540/1-88/001. Provides a framework for the assessment of exposure to contaminants at or migrating from hazardous waste sites. Discusses modeling and monitoring* (U.S. EPA, 1988d).

CERCLA Compliance with Other Laws Manual — Office of Emergency and Remedial Response. The guidance is intended to assist in the selection of on-site remedial actions that meet the applicable or relevant and appropriate requirements (ARARs) of the Resource Conservation and Recovery Act (RCRA), Clean Water Act (CWA), Safe Drinking Water Act (SDWA), Clean Air Act (CAA), and other federal and state environmental laws as required by CERCLA, Section 121 (U.S. EPA, 1988b).

Guidance for Data Useability in Risk Assessment — Interim Final 1990. EPA/540/G-90/008 (U>S> EPA, 1990).

Federal Guidance Report No. 10 — The Radioactivity Concentration Guides -- Office of Radiation Programs (U.S. EPA 1984) EPA/520/1-84/010.

Federal Guidance Report No. 11 — Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion and Ingestion -- Office of Radiation Programs (U.S. EPA 1988e) EPA/520/1-88/020.

Data Collection and Evaluation

- Gather and analyze relevant site data
- Identify potential contaminants of concern
- Evaluate uncertainty

Exposure Assessment

- Analyze contaminant releases
- Identify exposed populations
- Identify potential exposure pathways
- Estimate exposure concentrations for pathways
- Estimate contaminant intakes for pathways
- Evaluate uncertainty

Toxicity Assessment

- Collect qualitative and quantitative toxicity information
- Determine appropriate toxicity values
- Evaluate uncertainty

Risk Characterization

- Characterize potential for adverse health effects to occur
 - Estimate cancer risks
 - Estimate noncancer hazard quotients
- Evaluate uncertainty
- Summarize risk information

PREPARED FOR:

U.S. DEPARTMENT OF ENERGY

Rocky Flats Plant
Golden, Colorado

FIGURE 8-1

TITLE:

HUMAN HEALTH RISK ASSESSMENT

PROJ. NO.	304909	DWG. NO.	4909-A72	SHEET
DESIGN BY	B. ROTHMAN	CHECKED	<i>BR</i>	OF
DRAWN BY	KRONER	APPROVED		
DATE	10-22-91	SCALE	NA	

9.0 ENVIRONMENTAL EVALUATION

9.1 INTRODUCTION

The objective of this Environmental Evaluation Work Plan (EEWP) is to provide a framework for addressing and quantifying the ecological effects on the biotic environment (plants, animals, microorganisms) from exposure to contaminants within OU4, the Solar Ponds. This EEWP is based on an ecosystem approach to ecological risk assessment to ensure that effects of contamination at the ecosystem level of biological organization are also considered (U.S. EPA, 1989c). The ecosystem approach is comprehensive in that it initially integrates all ecosystem components, then progressively focuses on aspects of the system such as populations, structure, productivity, or diversity that are potentially affected by contamination. This approach allows decisions to be made on choices of sampling and analysis for determining effects. The result is an evaluation of the nature and extent of contamination in biota, its relationship to abiotic sources, and the type and extent of adverse effects at the ecosystem, population, and community levels of biological organization.

This plan conforms to the requirements of current applicable legislation, including CERCLA, as amended by SARA. Guidance was provided by the NCP and EPA documents for the conduct of RCRA RFI/RI activities. Specifically, guidance was taken from *Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual* (U.S. EPA, 1989c) and *Ecological Assessment of Hazardous Waste Sites* (EPA 1989d). Although a formal Natural Resource Damage Assessment (NRDA) process has not been initiated at Rocky Flats, this EEWP was also designed to be consistent with the NRDA process to the maximum extent possible.

Determination of the effects on biota from exposure to contaminants will be performed in conjunction with the human health risk assessment for OU4. Where appropriate, criteria necessary for performing the Environmental Evaluation (EE) will be developed in conjunction with human health risk assessments and environmental evaluations for all Rocky Flats operable units. Information from the environmental evaluations will assist in determining the type, feasibility, and extent of remediation necessary for OU4 in accordance with RCRA.

Documents reviewed during preparation of this EEWP include the Final Environmental Impact Statement (EIS), Rocky Flats Plant (U.S. DOE, 1980); the Draft Final Phase 1 RFI/RI Work Plan for OU7 (EG&G, 1991f); the previous draft Phase 1 RFI/RI Work Plan for OU4 (U.S. DOE, 1990b);

and the proposed IM/IRA Decision Document for OU4 (U.S. DOE, 1991b). New data generated by the implementation of this Phase I Work Plan and other sitewide studies will be reviewed as they become available. This EEWP will be coordinated with the interim remedial actions being planned for the Solar Ponds which is scheduled to start during the implementation of the ecological field studies (see Section 9.2.3).

An initial site visit was conducted at OU4 to note present site conditions, the nature and extent of terrestrial and aquatic ecosystems, and plant and animal habitats. The study area for the EE was preliminarily defined to help scope the investigation as well as to physically locate the study area in relationship to the downgradient Walnut Creek (OU6) and Woman Creek (OU5). There is not a no-action scenario for conducting this EE since, by necessity and at a minimum, the work plan must take into account present plans to evaporate the water in the ponds and begin the implementation of additional interim remedial actions. Other activities for pond closure and transfer or fixation of wastes will also be evaluated for future conditions and effects on the environmental evaluation such as contaminant form and concentration and potential for release into environmental media.

9.1.1 Approach and Scope

This plan presents a comprehensive approach to conducting the EE of OU4. Guidance for development of this EEWP was taken from EPA's *Environmental Evaluation Manual* (U.S. EPA, 1989c). This approach was designed to ensure that all procedures to be performed are necessary and appropriate to adequately characterize the nature and extent of environmental effects to biota under a remediation and future conditions scenario. The approach presented in this plan is adapted from the toxicity-based assessment of ecosystem effects (U.S. EPA, 1989c). This is based on standard risk assessment concepts in that hazards from contaminants are assessed for toxicity, exposure is determined, and impacts and risks characterized. Uncertainties with regard to potential ecosystem effects are explicitly recognized and, where possible, quantified. The planned approach for the OU4 EE is designed to provide weighted "best evidence" as to whether estimated damage is due to the contamination in question.

Three types of information will be used (U.S. EPA, 1989d):

1. Chemical - Sampling and analyses to establish the presence, concentrations, and variability of distribution of specific toxic compounds (to be conducted under the RFI/RI abiotic sampling program)

2. Ecological - Ecological surveys to characterize the condition of existing communities and establish whether any adverse effects have already occurred
3. Toxicological - Toxicological and ecotoxicological testing to establish the link between adverse ecological effects and known contamination

These three types of data are necessary to exclude factors other than contamination as the source of apparent ecological impacts at the study site.

The ecological assessment scheme adopted for the OU4 EEWP blends standard risk assessment methods with ecological and toxicological modeling to produce an integrated procedure for selecting Contaminants Of Concern (COCs) and target species and for conducting an investigation of ecosystem effects resulting from contamination. As recommended by EPA (U.S. EPA, 1989c), the EE is not intended to develop into a research-oriented project. The EEWP is designed to provide for a focused investigation of the potential effects of contaminants on biota at OU4. Contamination that occurs outside the boundaries of OU4 as a result of migration of contaminants in adjacent watersheds or drainages will be integrated with other OU environmental evaluations for potential effects. Migration of contaminated surface or ground waters could potentially cause ecological effects in the Walnut Creek and Woman Creek drainages.

The EE tasks identified at OU4 will be coordinated with RFI/RI activities at other operable units at Rocky Flats. Coordination with OU5 (Woman Creek) and OU6 (Walnut Creek) activities will be particularly important because OUs 5 and 6 are located down slope and down gradient of OU4. Contamination from the Solar Ponds has potentially migrated and impacted ecosystems within these drainages.

The general methodology for conducting the EE for OU4 can be described as implementing four major steps: contaminant identification, exposure assessment, toxicity assessment, and impact/risk characterization. The ecological assessment using the ecosystem approach has additional needs in developing the information and data base. These needs include: ecological site characterization for biotic and abiotic factors, determining contaminants of concern and target species, and developing and implementing a sampling and analysis plan. Conceptual models for food webs, transport, exposure, uptake and determining effects need to be developed during the implementation of the EE. Selection of ecological measurements, "endpoints", for determining effects depends on identifying contaminants and target species or ecosystem processes from site specific data.

The EE for OU4 is divided into ten tasks for developing data and information and implementing the procedures. These tasks and their interrelationships are shown in Figure 9-1. The tasks are summarized below. A more detailed description of task activities is presented in Section 9.2.

Task 1: Preliminary Planning and Conceptual Model Development

Task 1 was partially completed during preparation of this Work Plan. Additional work will focus on planning and coordination necessary to carry out the detailed planning and implementation of the OU4 EE with other OU4 RFI/RI activities and with EEs for other operable units. Task 1 will include a detailed determination of the scope of work and definition of the study area. Methods for developing Data Quality Objectives (DQOs) will be refined and implemented in Task 1 according to EPA guidance (U.S. EPA, 1987), and procedures for monitoring and controlling data quality will be specified. Criteria developed for selection of contaminants of concern, target species, and reference areas (if needed) will be reviewed and used. Conceptual models for conducting the EE, such as pathway analysis, exposure assessment, food webs, and ecological effects will be developed.

Task 2: Data Collection/Evaluation and Preliminary Risk Assessment

Task 2 was also partially completed and will include further review, evaluation, and summary of available chemical and ecological data, formation of data groups, and identification of data gaps. The information will be compiled into an integrated data base. The study site will be further characterized for existing ecological parameters for abiotic factors, ecosystems and habitats present, and biotic resources during Task 3. Information and data gaps will be identified. Based on existing data, a preliminary assessment of risks to biota and the environment will be performed for use in completing and verifying the list of COCs presented in Section 9.2.2.4. As part of this preliminary ecological risk assessment, the food web model will be utilized and preliminary exposure pathways will be identified. Results of this task will be used to refine the ecological and ecotoxicological field investigation sampling designs, and the field sampling plans.

Task 3: Ecological Field Investigations

Task 3 will include preliminary field surveys and an ecological field inventory to characterize OU4 biota and their trophic relationships, and to note locations of obvious zones of chemical contamination. The site characterization program will identify and describe the environmental media important for the EE. Brief field surveys of vegetation types in OU4 will be conducted to obtain information on the occurrence, distribution, variability, and general abundance of important or widespread plant and animal species. The need for any qualitative aquatic surveys for this task will

be determined based on site investigations (U.S. EPA, 1989e). Field inventories will be conducted in late spring and summer to obtain quantitative data on community composition in terrestrial and, if present, aquatic habitats. Samples collected as part of the activity may be preserved for tissue analyses, where COCs have been identified. Task 3 may possibly include aquatic toxicity tests of pond or surface water and sediment using standard tests only if there is water present that is determined to be a hazard due to contamination. As part of these activities, all collected field data will be reduced, evaluated, compared with, and integrated into the existing data bank to update knowledge of site conditions.

Task 4 through 7: Contamination Impact Assessment

Task 4: Toxicity Assessment

Task 4 will entail compilation of toxicity literature and toxicological assessment of potential adverse effects from COCs on target taxa. Potential effects on target taxa will be identified and compared to exposures relative to values from literature. Toxicity profiles and values for COCs will be developed, and other types of effects such as biomarkers or ecosystem disfunctions will be determined. This task will be performed in conjunction with Task 5.

Task 5: Exposure Assessment and Pathways Model

In this task, site-specific pathways model(s) will be verified based on the ecological field investigation and inventory. This source-receptor pathways model will be used to evaluate the transport of OU4 contaminants to target taxa, the biological receptors. The pathways model is based on a conceptual pathways approach (Fordham and Reagan, 1991) which describes the actual or potential contaminant releases and an initial determination of the movements and distribution of contaminants. The likely interactions among ecosystem components, and expected exposures, chemical intake, and impacts to biota will be determined. Exposure intake and level of dose will be estimated or determined by measurement of concentration in media and biotic material, or through literature values. This effort will be coordinated with those of investigations in other operable units to avoid duplication of effort and to ensure consistent data collection techniques and consistent assessment of environmental risk.

Task 6: Preliminary Contamination Risk Characterization

Task 6 will provide an analysis of the actual or potential risk to ecological receptors posed by actual or potential exposure to OU4 contaminants and a summary of risk-related data pertaining to the site. Determinations will be made as to the magnitude of the effects of contamination on OU4 biota. The actual or potential effects of contamination on ecological endpoints (e.g., species diversity, food web structure, productivity) will also be addressed. Depending on the DQOs and the quality of data collected, the contamination risk characterization will be expressed qualitatively, quantitatively, or as a combination of the two, using a "weight of evidence" approach. If sufficient information is available, Task 6 may also include preliminary derivation of remediation criteria. Development of these criteria will include consideration of (1) federal and Colorado laws and regulations pertaining to preservation and protection of natural resources and (2) RCRA risk-based criteria (or other criteria; see Section 9.2.1.4) for concentrations of contaminants in environmental media.

Task 7: Uncertainty Analysis

Task 7 includes identifying assumptions and determining sources of error for evaluation of uncertainty in the environmental risk assessment analysis. Information will be summarized for the analysis of magnitudes of uncertainty and address the level of confidence in the quantitative values presented in the risk characterization. The analysis will specify sources of uncertainty and limitations of the EE. Task 7 will also include identification of data needs to calibrate and validate the exposure pathways models developed in Task 5.

Task 8: Final Planning for Field Investigations

Task 8 will include planning of field sampling activities and development of additional DQOs with respect to the conduct of the ecotoxicological field investigation and tissue sample analysis. The need for measuring additional population endpoints (such as reproductive success or enzyme inhibition) will be evaluated on the basis of the Task 3 preliminary ecological risk assessment. DQOs to be achieved by such sampling will be defined according to EPA guidance (U.S. EPA, 1987). Scoping and design of the Task 8 field studies will be based initially on the outcome of the Task 2 preliminary ecological risk assessment and results of Task 3 field activities. The program will develop more specific DQOs, select field methodologies and refine the field sampling plan. Field sampling will be performed only where acceptance criteria for demonstrating injury to a biological resource will be satisfied in accordance with regulations under the NRDA (43 CFR Subtitle 1, Section 11.62 [f]).

Task 9: Ecotoxicological Investigations

Task 9 will include collection of samples for tissue analysis and any additional ecotoxicological field investigations according to the revised FSP developed in Task 8. Samples collected in Task 3 field studies will be used when possible (e.g., when contaminants of concern have been identified and sampling protocols are in place); new samples will be collected if necessary. Task 9 will also include tissue analysis studies for concentration of contaminants and correlation with concentrations in environmental media. Additional ecotoxicological field investigations may be conducted to collect data, measure effects and validate exposure or dose models. A complete data validation will be performed at the completion of this task.

Task 10: Environmental Evaluation Report

Results from Tasks 8 and 9 will provide a additional characterization of contamination effects on biota at OU4 and will be used in the further evaluation of population or ecosystem effects in a final contamination risk assessment. Information on site environmental characteristics and contaminants, characterization of effects, remediation criteria, conclusions, uncertainty analysis, and limitations of the assessment will be summarized in the EE report. An initial draft report will be written which includes remediation criteria.

Each of the preceding tasks is described in further detail in Section 9.2. The field sampling plan presented in Section 9.3 addresses both the Task 3 ecological investigation and the Tasks 8 and 9, ecotoxicological field investigations.

9.1.2 Contamination Summary

A summary of the contamination that could impact ecological receptors is presented in this section; data pertaining to the nature of contamination are presented in detail in Section 2.5. The data needed to fully characterize contamination at OU4 are insufficient and sometimes lack validation/verification. Therefore, more extensive data will be collected during the soil sampling programs in this RFI/RI and will be used in the assessment of contamination potentially harmful to biota. Additional soil sampling locations for the EE may be required to measure contaminant concentrations in relation to biota, and identify the availability of nutrients and other ecologically relevant soil conditions.

Review of the information on the Solar Ponds area (Rockwell International, 1988a; Dames and Moore, 1991; and U.S. DOE, 1991b) and information supplied on soil surveys indicates that

contamination has resulted from emplacement of fluids containing process waste materials in the ponds. The process wastes in the pond liquids contain nitrates, heavy metals, some volatile compounds, and radionuclides. A summary of these potential contaminants are presented in Tables 9-1, 9-2 and 9-3. The tables are incomplete since some of the information has yet to be verified and the summary tables were constructed from other reports. In Table 9-2, uranium of an unknown isotope is recorded because of a high reported concentration. In Table 9-3, volatile organic concentration values from the ITS water samples were not validated. Results from environmental samples indicate that leakage from the ponds has contaminated soils and ground water. Additionally, it is highly suspected that contamination has been released and deposited onto soil surfaces through air pathways from routine maintenance and cleanup activities.

The interceptor trench system (ITS) constructed on the hillside northeast of the ponds collects ground water and pond leakage. ITS water flows by gravity to a sump and is pumped into the 207-B pond. This seepage water contains inorganic materials, mostly nitrates, radionuclides and low levels of volatile compounds.

9.1.2.1 Approach to Identification of Contaminants of Concern in the EE

COCs are chemicals associated with activities at a hazardous waste site that are suspected to occur in environmental media. They have the potential to damage natural populations or ecosystems. In this context, the word "chemicals" includes organic compounds, inorganic compounds, radionuclides, ions, and elemental metals. The list of COCs will be used to select target analytes for testing biota and/or environmental media for contamination amounts and chemical forms.

Depending on physical properties, contaminants may become differentially distributed among environmental media or among components within a medium. The result may be differential exposure of species or populations to the contaminant. The factors affecting distribution in environmental media include:

- Persistence -- The resistance to degradation by abiotic or biotic processes
- Volatility -- The tendency to volatilize, thus reducing soil or water concentration
- Mobility -- The degree to which a chemical tends to migrate within or between environmental media, thus placing further resources at risk; or the chemical is strongly absorbed or adsorbed on soil or sediment particles

- Solubility - The solubility in aqueous solutions, which may affect mobility in surface and ground water
- Differential Accumulation - The tendency to segregate into different environmental media or components of a single medium.

These factors will be considered when developing a target analyte list for analyses of specific organisms, tissues, or abiotic media.

9.1.3 Terrestrial and Aquatic Ecosystems and Habitats

An initial site visit was conducted on OU4 to determine the extent of the ecosystems and habitats present on the site and to determine the study area for OU4 in relationship to other OUs. The location and configuration of the Solar Ponds are given in detail in Section 2.0. This Section also includes former and current uses, management, and process wastes handled. An interceptor trench system to the north of the ponds collects seepage water which is pumped back to the ponds. The configuration of the ponds and location in relationship to adjacent drainages and managed pond systems are described in Section 2.0 and shown in Figures 2-2 and 2-22. Because the ponds and surrounding area are within a high security area, a chain-link fence excludes large mammals and limits access to smaller animals. Other site characteristics of topography, hydrology, and geology that will affect the pathway analysis in the EE are discussed in Section 2.0. There is no information currently available for basing the OU4 EE on contaminant concentration in the biota.

The ecosystems and habitats at OU4 and in the proposed study area have been highly altered by construction and operation of the ponds and other surrounding facilities. There are no natural ecosystems present, although the OU4 unit has some vegetation reestablished by reseeding and natural seeding (mostly weeds) and some wide ranging and hardy animals. The following is a brief description based on the initial site visit and general information in other reports.

9.1.3.1 Types, Condition, and Extent

The terrestrial ecosystems are highly modified and in the first stages of revegetation by plants and invasion by smaller animals. Weedy vegetation has established on and around the ponds on bare soil in adjacent level construction fill, and in cracks in liners. The fill slope to the north of the ponds has a grass/weed vegetation with small wetlands developed around two seeps. Arthropods and other invertebrates were observed on plants and birds occasionally visit the site. Small mammals such as deermice are expected. Cottontails were seen and scat from either a fox or a

coyote was observed. There are no wetlands in the OU4 area, but the impact and study area contains small seeps and seasonal wetlands. Aquatic ecosystems are lacking on OU4 and the study area which is at the head of a drainage and there are no streams or natural bodies of water. The ponds cannot be considered as aquatic ecosystems due to use and management practices and the lack of viable aquatic organisms and food webs. Algae mats seasonally grow on the ponds and were observed on Pond 207-B North during the site visit in September 1991. The areas to the north and east are the drainages of Walnut Creek which have both terrestrial and aquatic ecosystems. These could potentially be impacted by contaminants from OU4. As mentioned previously, North Walnut Creek is a separate OU and its EE will be coordinated with the EE for OU4.

Habitats in the area were identified according to SOP 5.11 - Identification of Habitat Types (Figure 9-2). Habitats at OU4 and the study area are greatly influenced by the ponds construction and uses and are all disturbed types. The main habitat on OU4 is disturbance/barren land areas with a few areas of the cheatgrass/weedy forbs habitat. Although there is open water at present in the Solar Ponds as impoundment type habitats, this open water has little aquatic biota and is being evaporated and not replaced. It is not expected to be present by the time this EEWP is implemented. Waterfowl are reported to land on the ponds although they do not use the ponds for nesting or feeding. The proposed study area includes the fill slope to the north and a portion of the area on the interceptor trench system which has a mixed grassland complex of seeded and adventive plant species, and small areas of short marsh around seeps.

No systematic assessment of vegetation cover and species richness or animal species was conducted in the September 1991 site visit. Observations were made on the plant species present and notes on the presence or signs of animals.

9.1.3.2 Biotic Taxa

The biotic species observed and known to be present on OU4 and the proposed study area are small in numbers and diversity compared to the RFP and surrounding area. This lack of numbers and diversity is due to the large bare areas, fragmentation and small areal extent of plant communities, limited access, and the weedy and grass habitat in the first stages of establishment and succession. Plants species are primarily grasses and weedy forbs with no shrubs or trees. Animal species are those adapted to disturbances or are wide ranging, mobile, and able to penetrate the fencing. The higher trophic levels of consumer and predators are few, and those present are in small numbers or are occasional visitors not restricted to the ecosystems at OU4.

9.1.3.3 Protected Species and Habitats

OU4 has a restricted area with controlled access and no areas of natural habitat. Use of the area by endangered species of plants and animals is reduced due to lack of habitat. Endangered animal species potentially of interest in the Rocky Flats area are the black-footed ferret, peregrine falcon, and bald eagle (EG&G, 1991m). Black-footed ferrets are not known to occur in the vicinity of RFP, and their critical habitat consists primarily of colonies of its major food item, the prairie dog. Prairie dog colonies do not exist in the Solar Ponds area. Bald eagles occur occasionally in the RFP area, primarily as irregular visitors during the winter or migration seasons. No roost areas or nest sites exist at RFP. Peregrine falcons may occur as migrants. A pair has reportedly nested approximately 10 km to the northwest in 1991. It is possible that the hunting territory of the nesting peregrines will include Rocky Flats, although suitable habitat and prey is lacking at the Solar Ponds.

Other wildlife species of higher federal interest that are potentially present at RFP include the white-faced ibis, mountain plover, long-billed curlew, Preble's meadow jumping mouse, and swift fox (EG&G, 1991m). To date, these species have not been documented to occur at RFP. An additional species, the ferruginous hawk, is known to occur near RFP and is likely to visit the site as a migrant or winter vagrant. Ferruginous hawks may also breed in the RFP vicinity; if so, their hunting territory could include RFP. Hunting territory and potential nesting sites of scattered trees and rocky ridge tops do not exist at OU4.

Four plant species of special concern that are potentially present include one species proposed for federal listing as a threatened species (*Diluvium lady's tresses*), one species of high federal interest (Colorado butterfly plant), and two species of concern in Colorado (forktip three-awn and toothcup). One of these species was found at RFP during a recent survey; forktip three-awn was recently found along a railroad grade and also reported along Woman Creek in 1973 (EG&G, 1991m). No potential habitat for these species exists within the study area for OU4.

Several wetlands identified at RFP are protected under state and federal laws (EG&G, 1990c). Wetlands at RFP were identified in conjunction with the National Wetlands Inventory (U.S. Fish and Wildlife Service, 1979) and field checked by U.S. Army Corp of Engineers personnel to verify their jurisdictional status. Areas officially designated as wetlands at RFP include reaches of an unnamed tributary to Walnut Creek and the East Landfill Pond. These wetlands consist of emergent, intermittently flooded stream channels and artificial, semipermanent ponds (wetlands types PEMW and POWKF, respectively; see U.S. Fish and Wildlife Service, 1981). Small marshy areas occur

on the study area around seeps. Wetlands downstream along Walnut Creek in OU6 are dominated by a narrow band of cattails with occasional cottonwoods, willows, and other shrubs.

9.2 ENVIRONMENTAL EVALUATION TASKS

This EE will include qualitative and quantitative appraisal of actual and/or potential injury to biota, other than humans and domesticated species, due to contamination at OU4. The procedures are intended to reduce the uncertainty associated with understanding the environmental effects of contaminants and remedial actions.

The following plan for OU4 provides a framework for review of existing data, the conduct of subsequent field investigations, and preparation of the contamination risk assessment. Methodologies for the ecological and ecotoxicological field investigations (Tasks 3 and 8) are described in the Field Sampling Plan (FSP) presented in Section 9.3.

9.2.1 Task 1: Preliminary Planning and Conceptual Model Development

This task includes coordination of the EE with other studies of the RFI/RI tasks and adjacent OUs, determination of the scope of the EE and study area, detailed conceptual model developments and decision points, identification of DQOs, and a selection of COCs, target species, and reference areas. Portions of the planning were completed for this EE Work Plan that included review of some reports, an initial site visit for site biota and environment, and preparation of the FSP.

9.2.1.1 Coordination with RFI/RI Work and Other Operable Units

During this task, the EE work will be coordinated with the human health risk assessment for OU4, adjacent offsite OUs, and the site characterization studies for contaminants in environmental media. Sample sites for biota and contaminants will be coordinated with the field sampling plan for OU4, and the EE field sampling plan will be tied into those for Walnut and Woman Creek to avoid duplication. The COCs for the OU4 EE will be used to suggest surveys, measurements, and collection of samples on the adjacent OUs. Information developed for these OUs will be compared to OU4. Environmental pathways for fate and transport of contaminants, toxicities, and exposures will be compared to those used in the human health risk assessment. This is a continuing task that will require coordination throughout the various tasks to conduct the EE investigations.

9.2.1.2 Define Scope and Study Area

The final scoping of the EE tasks and study area will describe the kind and amount of information that will be collected in the study area. The ecological parameters that are to be measured, estimated, and calculated will be refined. The time frame and boundaries of the study area will be designated to correspond with seasonal biological sampling. The boundary of the study area will extend beyond the boundaries of OU4 but will be integrated with boundaries for EEs at adjacent OUs.

9.2.1.3 Data Quality Objectives

The primary objective of the EE is to collect data necessary during the RFI/RI process to quantify risks to ecosystems or components. There are developed in conjunction with the RFI/RI procedures. Preliminary DQOs for Task 3 activities were developed according to the process prescribed by EPA (U.S. EPA, 1987). DQOs for Task 9 field activities will also be developed using this process. The DQO development process as recommended by EPA includes three stages:

- Stage 1 - Identify decision types -- The decisions and data users for which the data will be collected to support will be defined. Available data and a conceptual model for the study area will be developed so that specific objectives can be formulated.
- Stage 2 - Identify data uses and needs -- The specific uses and types of data needed to meet specific objectives will be defined. The quality and quantity of the required data, including resolution and sample size, will be estimated.
- Stage 3 - Design data collection program -- The methods by which data are to be collected will be outlined and documented. QA/QC methods will be developed and documented.

Existing environmental data and the site conceptual model presented in Section 2.0 will be used to assess potential exposure points and pathways, and general objectives of the sampling program will be identified. Based on the types of data needed to address the objectives, sampling locations and methods will be better identified. Final details of the field program defined in the field sampling plan (Section 9.3) will be reviewed prior to the beginning of fieldwork. At that time, it will be verified that sampling locations and methods are appropriate for existing conditions.

9.2.1.4 Selection Criteria for Contaminants of Concern, Target Analytes and Taxa, and Reference Areas

In preparing this EEWP, a list of COCs was preliminarily identified using the criteria presented below and is presented in Section 9.2.2.4. These criteria were developed in concert with EG&G and

have been reviewed by EPA. The list identified is preliminary because of the limited amount of data available at the time this work plan was prepared. The final identification of COCs will be based on criteria in three general categories: documentation of occurrence of the chemical in environmental media, ecotoxicity of the chemical, and extent of contamination at the site. Existing data from analysis of biological samples will also be used to determine occurrence of a contaminant. These criteria are discussed in more detail below.

- Occurrence - The known or suspected occurrence of a chemical in environmental media will be ascertained from:
 - Existing data from abiotic media (soil, water, air), or from biota
 - Waste stream identification and disposal practices
 - Process analyses to identify potentially hazardous substances used in large quantities
 - Historical accounts of use or accidental release.

The resulting list of chemicals will then be evaluated for ecotoxicity and the extent of contamination at the site.

- Ecotoxicity - For purposes of inclusion in COCs, the ecotoxicity of a chemical will be determined from its documented adverse effects on biota, or potential for intensifying of toxic effects of other chemicals. A chemical will be considered for inclusion on the list of COCs if, at levels detected within the OU, it exhibited:
 - Acute and chronic toxicity, including mortality and teratogenicity; or
 - Sublethal toxicity, including reduced growth rates, reduced fecundity, and behavioral effects; or
 - Toxicity resulting from bioaccumulation due to absorption of the chemical directly from environmental media or ingestion of contaminated food items.

The above information will be extracted from federal or state regulatory guidelines, chemical information and data bases, or scientific literature. The resulting list of chemicals will then be evaluated for extent of contamination at the site.

- Extent of Contamination - The extent of contamination may result in significant exposure of ecological receptors. The EE will make full use of existing data for assessing the nature and extent of contamination of abiotic media at OU4 as determined and summarized in Section 2.3. A chemical will be included on the list of COCs if:

- It is present above natural background concentrations as determined by the "Annual Background Geochemical Characterization Report" for the RFP;

and either

- It is present above regulatory standards or ARARs;

or

- It is present above risk-based "acceptable levels";
- or both.

In addition, a chemical may be included as a COC if:

- It is reported in greater than five percent of the samples analyzed for a given area;

and at least one of the following:

- It is widely distributed; or
- It occurs in ecologically sensitive areas such as wetlands or seeps which may serve as a drinking water source for wildlife; or
- It occurs in localized areas of high concentration ("hot spots").

Chemicals that satisfy the above criteria for occurrence, toxicity and extent will be identified and are discussed in Section 9.2.2.4.

Selected target biotic taxa will reflect the biological populations present at OU4 that are affected, have the potential for impacts from contamination, or can be measured by contaminant concentrations (see Section 9.2.2.4). The selection criteria will follow guidelines recently proposed by EG&G (EG&G, 1991u). The plant and animal species that can potentially be selected by these criteria are limited at OU4 by the restricted and incomplete ecosystems present on the study area. These ecosystems lack complexity due to few primary producers and the absence of species in higher trophic levels. The taxa selected at OU4 will partially reflect those that are present in sufficient numbers or biomass to measure or collect.

The location of a reference area, if needed, will be determined based on habitat type, habitat size, slope and aspect, and soil type. General soil types should be similar and take into account disturbance and loss of topsoil where appropriate. Notable differences between study and reference sites must be reported. All of these criteria for a reference area, especially a disturbed and secured area, will probably not be met. A reference area for OU4 may not be necessary.

9.2.1.5 Develop Conceptual Models and Food Web Analysis

Detailed conceptual models for determining ecological impacts will be developed for defining the scope of the EE. These conceptual models provide the following elements in the contaminant ecological impact (risk) assessment:

- contaminants release scenarios
- migration, pathway analysis and transport media
- exposure routes and intake/dose measurements or estimates
- types and magnitude of effects on target taxa.

Other models may be used to compare values of contaminant target analytes measured in environmental media to concentrations in biological tissue. These then can be compared to known toxicity values. While food web analyses in the form of flow paths and charts help to define impacts in food chains, these types of analyses will have limited utility in the disturbed ecosystems at OU4.

9.2.2 Task 2: Data Collection and Evaluation, Preliminary Risk Assessment

Task 2 will focus on additional accumulation and analyzation of pertinent information in three major areas:

1. Species, populations, and food web interrelationships
2. Types, distribution, and concentrations of contaminants in the abiotic environment (e.g., soil, surface water, ground water, and air)
3. Preliminary determination of potential exposure pathways and potential contaminant effects on OU4 biota based on literature review.

The principal subtasks remaining in Task 2 include: collecting information, data and literature review, and evaluation; ecological site characterization; a preliminary ecological risk assessment of contaminant impacts; and final identification of COCs, target species and reference areas. The final task is reviewing the field sampling approach and detailed design. These subtasks will be performed in conjunction with the Task 3 Ecological Field Investigation and include a sampling design with COCs, target species, and analytes identified. Information that will be developed from these tasks includes the following:

- COCs - Existing information regarding the nature and extent of contamination at OU4 will be reviewed and used to develop and better define the preliminary list of COCs. Final Selection of COCs will follow criteria established by EG&G, although this list will be periodically reviewed.

- Descriptive Field Surveys - Ecosystems, habitats and biota of OU4 will be inventoried. Observations will be made on locations of obvious zones of chemical contamination, ecological effects, and human disturbance.
- Species Inventory - Plant and animal species known to occur within OU4, or to potentially contact contaminants from OU4, will be identified along with their trophic relationships.
- Population Characteristics - General information on the composition of ecologically functional groups and the abundance of important species in those groups will be collected.
- Functional Groups Within Ecosystems - Available information from literature sources to supplement field observations will be collected. Possibly collect productivity or biomass samples and analyze for target taxa or functional groups.

9.2.2.1 Collect and Evaluate Existing Site Data and Information

An essential component of Task 2 is the additional review of available documents, aerial photographs, and relevant site data. This review will allow compilation of a data base from which to determine data gaps and will provide the basis for developing the field sampling program. Studies conducted by DOE and RFP operating contractors will be reviewed and evaluated. Further information to be reviewed will include the following:

- Project files maintained by EG&G
- Project reports and documents on file at Front Range Community College Library and the Colorado Department of Health
- DOE documents and DOE orders
- Phase I data base
- RFEDs (database)
- Data from ongoing environmental monitoring, EEs from other operable units, baseline vegetation and wildlife studies, and NPDES programs
- Studies conducted at Rocky Flats on radionuclide uptake, retention, and effects on plant and animal populations
- Scientific literature, including ecological risk assessment reports from other DOE facilities (Oak Ridge, Los Alamos, Hanford, Savannah River, and Fernald).

If available and applicable, historical data will be used. Where the same methods are not to be used in collection of new data, compilation of historical data will depend on the demonstrated compara-

bility of the data collection methods. This review and evaluation will identify information gaps in the ecological site and contaminant characterization, and help define data needs and objectives.

9.2.2.2 Ecological Site Characterization

Environmental and ecological resources at OU4 will be characterized on the basis of reviews of existing literature and reports, including results from the RFI/RI site characterization and other operable unit RFI/RI's. This information will be compiled and used in the preliminary risk assessment for pathway and exposure analysis. The description of the site will be presented in terms of the following resource areas:

- Meteorology/Air Quality
- Soils
- Geology
- Surface and Ground Water Hydrology
- Terrestrial Ecosystems.

Aquatic ecosystems and protected/sensitive species and habitats are not expected to be significant on OU4.

The purpose of the site characterization is to describe resource conditions as they exist now and the changes during scheduled interim remedial actions. The narrative with supporting data will include descriptions of each resource. There will be appropriate tables and figures to clearly and concisely depict site conditions, particularly as they influence contaminant fate and transport and the likelihood that the contaminants will adversely affect the ecosystems.

Terrestrial and aquatic species in the RFP area have been described by several researchers: Quick, 1964; Weber et al., 1974; Winsor, 1975; Clark, 1977; Clark et al., 1980; CDOW, 1981; and CDOW, 1982a, 1982b. Most of these reports are summarized in the Final EIS (U.S. DOE, 1980). In addition, terrestrial and aquatic radioecology studies conducted by Colorado State University and DOE (Johnson et al., 1974; Little, 1976; Hiatt, 1977; Paine, 1980; Rockwell International, 1986b), along with annual monitoring programs at RFP, have provided information on plants and animals in the area and their relative distribution. More recent data on species distribution and abundance can be obtained from the baseline vegetation and wildlife studies and EEs underway at OUs 1, 2, and 5. These studies are scheduled for completion in FY92 and FY93.

The preliminary list of important species present on the site, compiled from background information and the initial site visit, will be completed on the basis of observations of the presence and abundance of species during ecological site surveys and on a general trophic-level model. Based on the model, a modified list of species will be compiled using toxicological information (toxicity assessment) to determine which species or species groups might be most affected by, or most sensitive to, the COCs.

Data from past studies and preliminary data from current environmental studies will be used to identify background information and data gaps to better define the present distribution of contaminants from the abiotic environment and to develop an initial food web model. The food web model may be used in conjunction with exposure values, if a preliminary pathways analysis identifies likely or presumed exposure pathways or combinations of pathways and uptake from producers, such as grasses to receptor species. Based on this preliminary information, the Task 3 and Task 9 field investigation sampling approach/designs may be revised.

9.2.2.3 Preliminary Ecological Risk Assessment

The purpose of the preliminary ecological risk assessment is to define the contaminants at OU4 that possibly can affect the biota, determine possible exposure pathways, and evaluate possible impacts.

The assessment will use information and data collected and reviewed in the first portion of this task. Preliminary assumptions will be formed and the conceptual pathway will be used and tested. This assessment will be used in the next two procedures for selecting target species, contaminants of concern, and refining the scope of the field investigations. This preliminary assessment will also help determine informational needs or gaps in the data that will reduce the uncertainties in the final, more quantitative assessment.

9.2.2.4 Preliminary Identification of COCs, Target Species, Reference Areas

The criteria presented in Section 9.2.1.4 were applied to the potential contaminants and resulted in a preliminary list of COCs for terrestrial and aquatic sampling (Table 9-4). A comparison of potential contaminant data with the selection criteria is presented for OU4 in Table 9-5. The COC list is developed from the selection matrix which is presently incomplete. The list will be completed after the information on site-specific data is compiled and after additional site characterization sampling is conducted.

The final list of COCs to be used in the EE will be selected from the larger list of suspected contaminants attributed to OU4. The preliminary list of COCs was based on criteria developed by EG&G for the selection of COCs for EEs. These criteria include: physical properties of the chemical, such as solubility in water; resistance to chemical or biological degradation; and tendency to bioaccumulate. The criteria also include regulatory status of the chemical and factors relating to the nature and extent of contamination.

The target biota in the preliminary list (Table 9-6) were also selected using criteria developed by EG&G. Target biota were selected from a restricted list of possible taxa but follow the criteria of being important in the structure and function of the ecosystems present on the OU4 study area, or of being economically important in other ecosystems. The list of COCs, target analytes, and target taxa may be revised pending results of soil sampling and field surveys in and around OU4. These sampling programs are described in Section 7.0 of this RFI/RI Work Plan. The final list of COCs may include metals, organic compounds, and radionuclides. Analytes for specific tasks will be selected from the list of COCs.

Reference areas may be used to assess the impact of OU4 contaminants when available data are insufficient to do so and when appropriate reference areas are available. The decision to use reference areas and the criteria for selecting reference areas will ultimately depend on the ecological endpoints to be measured. The decision process for using reference areas is presented in Figure 9-3. Reference areas will be selected according to criteria in SOP 5.13 - Development of Field Sampling Plans. The reference site for OU4 may be located in the buffer zone to the north of the Rocky Flats Plant. Reference areas for terrestrial sites will be selected on the basis of habitat type (see SOP 5.11 - Identification of Habitat Types), soil series, topography, and aspect. Reference areas for aquatic sites will be not be selected unless indicated during the final planning stage for comparison with offsite aquatic ecosystems along Walnut Creek. Reference areas for tissue sampling will be located upgradient or upwind of potential contaminant sources at RFP.

The lists of COCs and target taxa will provide the basis for the contamination impact assessment (Tasks 4 through 7). In the contamination impact assessment, food webs and contaminant exposure pathways will be developed for OU4. Information on these food webs will be used to (1) relate quantitative data on contaminants in the abiotic environment to adverse effects on biota and (2) evaluate potential impacts on biota due to contaminant exposure.

Using the more complete data and information review and compilation, the field sampling design may be modified. Important concerns are the present concentration and distribution of contaminants in the abiotic media and the condition of the vegetation reestablished on disturbed areas in the study area.

9.2.2.5 Field Sampling Approach/Design

The FSP (presented in Section 9.3) helps to ensure that data and sample collection is consistent with the information objectives and DQOs developed for the EE. The FSP is designed to be flexible so that preliminary data and information can be used to modify and refine subsequent sampling efforts. Data and sample collection methods will be consistent with the Ecology SOPs (Volume V), and overall sample design will be consistent among tasks. Therefore, results from preliminary sampling in Task 3 will be compatible with results from subsequent sampling in Task 9.

9.2.3 Task 3: Ecological Field Investigation

The general Phase I RFI/RI field investigations for OU4 consists of the following separate programs for site characterization: (1) abiotic sampling for site characterization for the air program, which will entail emissions estimation and modeling; and (2) the soil sampling program, which will be conducted as part of the Phase I RFI/RI activities. The terrestrial biota sampling program is designed to use information from these programs and supplement with specific sampling relating to ecosystems, biota and habitat present.

9.2.3.1 Site Characterization Program

The site characterization program will provide information for validating conceptual models for pathway and exposure assessment. These survey and monitoring studies determine the abiotic parameters of air, soil and sediments, and ground and surface water that influence the rate of transport and fate of contaminants in the environment.

Air Quality

A sitewide air quality monitoring program is being conducted at Rocky Flats. The data may be used to model airborne transport of contaminants to potential receptors. Where the inhalation pathway is considered to be significant in the case of OU4 biota, a detailed pathways analysis and assessment of potential adverse effects using these transport model data will be performed. The airborne pathway has been suggested as the source of suspended soil radionuclide contamination from the

ponds. This is based on soil surveys conducted during the past year and from air samplers and soil contamination measurements.

Soils

Minimal data exist on contaminants present in surficial soil materials at OU4. Although boreholes have sampled soils and substrate in and around the ponds to various depths, the samples were collected from depths other than those relevant for ecological purposes. Recent surface soil samples, starting in June 1990, were taken west of Pond 207-A in the small area between the pond, Building 788, and a newly installed trailer. While these results have not been validated, they show elevated concentrations of plutonium (Pu) and americium (Am) at the approximate ratios contained in water and sludge in Pond 207-A. This sampling is continuing at locations to be determined. FIDLER surveys were conducted to confirm the elevated counts for Pu and Am around and between the ponds and provide data on berms around ponds. Results confirmed the elevated soil contamination measured and suggest a correlation between elevated FIDLER surveys and soil contamination.

The purpose of the Phase I RFI/RI sampling and analysis program is to provide data for characterizing OU4 and for confirming the distribution and concentrations of contamination. The Phase I RFI/RI Work Plan proposes collection of soil samples in OU4. The soil sampling and analysis program is presented in Section 7.0. In addition, soil analyses will be conducted in connection with biota sampling to determine uptake and possible bioaccumulation. This information will be used to evaluate the exposure and dose models being developed.

Surficial soil samples will be of prime importance for determining source contaminants for biota. This uppermost layer is a major source of nutrients and contaminant uptake for the vegetation under study. It is also a potential source of contaminant ingestion to soil dwelling animals and invertebrates, and their predators. Soil samples from all depths are related to surface water and ground water regimes. Fluids moving through the soils can leach contaminants, transport them through available flow paths, and deposit them in downgradient environments. Contamination in soil and ground water at a depth of greater than 20 feet (maximum depth of burrowing animals and plant root penetration) will not be considered to affect biota. Contamination at these depths may be considered if other RFI/RI studies (e.g., ground water studies) suggest that the contaminants may reach the surface.

The sampling and analysis programs under the Phase I RFI/RI field investigations will be reviewed and modified as necessary to ensure that sampling intervals and methods are appropriate for collection of surficial soil samples in the required locations. Data from the Phase I OU6 RFI/RI program will also be evaluated for use in characterizing the nature and areal extent of surface soil contamination in the vicinity of OU4. The information will be used to help identify exposure pathways for the contamination assessment.

Surface Water and Sediments

Surface water from the Solar Ponds area can flow toward North Walnut and South Walnut Creeks. Runoff is collected in ditches and natural drainages into two series of ponds in these two creeks. Surface water and sediment samples are collected on a regular basis as part of ongoing sitewide investigations. These investigations will continue. Discharges from the ponds are monitored as is the water collected by the ITS. All discharges are monitored in accordance with NPDES requirements, which also include radionuclides.

Ground Water

Ground water generally flows to the east of the Solar Ponds area in two connected ground water systems. In the surficial materials, ground water flow diverges in two directions: northeast toward North Walnut Creek and east-southeast toward South Walnut Creek. In weathered bedrock, the ground water also flows to the east. The ground water is influenced by topography and facilities construction and grading, seasonal recharge, the top of the bedrock, and the ITS. Inorganic constituents and radionuclides have been measured in the general Solar Ponds area and are present in the ground water and ITS seepage flow. This is a potential pathway for contaminants from ground water to contaminate vegetation around seeps and impact the plants and animals in these areas.

9.2.3.2 Field Investigations for Terrestrial Ecosystems

Field surveys will be conducted during Task 3 to characterize current ecological and biological site conditions in terms of species composition, habitat characteristics, and/or community organization. Methods identified and described in the Ecology SOPs (Volume V) (EG&G, 1991n) will be used in collecting biological data and samples. The emphasis will be on describing the structure of biological communities at OU4 in order to identify potential contaminant pathways, biotic receptors, and target species.

Initial site surveys will be conducted during the late fall/winter period, depending on the start of implementation of field work. These initial qualitative surveys can also be conducted in early spring. However they should precede the start of detailed surveys, sampling, and the collection of plants and trapping of animals for tissue samples. Detailed and quantitative field investigations are planned to coincide with the growing season in late spring/early summer and the maturation period in late summer/early fall. Exact timing will depend on the seasonal variation in weather and the phenological response of vegetation and animal reproduction. Additional abiotic sampling for exposure pathway and toxicity assessment may be decided from these surveys. There are no plans, at this time, to conduct aquatic surveys or aquatic toxicity testing.

Vegetation

The objectives of the vegetation sampling program are to provide data for: (1) description of site vegetation characteristics; (2) determination of impacts to plant communities; (3) identification of potential exposure pathways from contaminant releases to higher trophic-level receptors; (4) selection of target taxa for contaminant analysis to determine background conditions for OU4; and (5) identification of any protected vegetation species or habitats.

Wet Meadows Vegetation

Wet meadows type vegetation has been identified north of the Solar Ponds on the fill slope in the areas of surface seeps. These occur mostly as isolated areas that support hydrophytic vegetation species, including broad-leaf cattail (*Typha latifolia*), baltic rush (*Juncus balticus*), and various bulrushes (*Scirpus spp.*). Plots will be established in wet meadows vegetation habitats for collection of phytosociological data on density and species composition.

Terrestrial Wildlife

A field survey will be conducted to collect data on terrestrial wildlife in potentially affected areas. The objectives of this survey are to: (1) describe existing wildlife habitats in the OU4 area; (2) develop food web models, including contribution from vegetation; (3) identify potential contaminant pathways through trophic levels; (4) identify target species for collection and tissue analysis; and (5) identify threatened or endangered species.

The field survey will document the presence of terrestrial species and allow for a general description of the community. Some species (e.g., songbirds, small mammals, reptiles, and insects) may use

the area daily, seasonally, or sporadically. The field surveys will consider the use of OU4 habitats by these species.

The FSP (presented in Section 9.3) will help to ensure that data and sample collection are consistent with the information objectives and DQOs developed for the EE. The FSP is designed to be flexible so that preliminary data can be used to modify and refine subsequent sampling efforts. Data and sample collection methods will be consistent with the Ecology SOPs (Volume V), and overall sample design will be consistent among tasks. Therefore, results from preliminary sampling in Task 3 will be compatible with results from subsequent sampling in Task 9.

9.2.4 Contamination Impact Assessment (Tasks 4 through 7)

The contamination impact assessment includes Tasks 4 through 7. The two primary objectives of the contamination assessment are to (1) obtain quantitative information on the types, concentration, and distribution of contaminants in selected species, and (2) evaluate the effects of contamination in the abiotic environment on ecological systems.

Contamination impact assessment requires an evaluation of chemical and radiological exposures and the actual or potential toxicological effects on target species. Specifically, the assessment will identify exposure points, contaminant concentrations at those points, and potential impacts or injury. The contamination assessment for OU4 will be based on existing environmental criteria, published toxicological literature, and existing site-specific data. The program design will be integrated with other ongoing RFI/RI studies so that concentrations of contaminants in abiotic media can be related to biota exposures. Task 2 will include a preliminary ecological risk assessment based on the site characterization and identification of COCs. The preliminary Task 2 assessment will be used to revise the Task 9 ecotoxicological field investigation sampling design. The contamination assessment process described in the following tasks will include the review of the site-specific pathways model developed to assess the potential for contaminant exposure to, and adverse effects on, biota. The description of work for each of the contamination assessment tasks are presented below.

9.2.4.1 Task 4: Toxicity Assessment

This assessment will include a summary of potential adverse effects on biota associated with exposure to OU4 contaminants, and a comparison of estimated exposure concentrations relative to published values or concentrations at which toxic effects are known, based on toxicity profiles and contaminant concentrations. At this time, an uncertainty analysis of the toxicity information for this

site will be performed. Potential toxic effects on target taxa will then be characterized using EPA critical toxicity values (when available), in addition to selected literature pertaining to site- and receptor-specific parameters. The toxicity assessment will include brief toxicological profiles for COCs and their known distribution and fate in environmental media. The profiles will cover the major deleterious effects information available for each COC. Data pertaining to wildlife species will be emphasized, and information on domestic or laboratory animals will be used when wildlife data are unavailable.

Often there is not enough information in the existing literature to estimate intake rates, understand how contaminants are metabolized, or define acceptable intake levels on a toxicity basis. This is true for the concentration levels of contaminants already measured or expected on OU4 in environmental media. Exposure and dose are further reduced by transport and differential uptake in various species. In these cases, it may be more appropriate to develop a field program to measure an indicator of contaminant stress (toxicity) rather than undertake the extensive laboratory and field studies needed to assess the toxicity using the quantitative dose-response approach. These indicators of contaminant stress are referred to as "ecological endpoints" or biomarkers. Rather than trying to assess toxicity itself, the ecological endpoint approach measures a specific end result of toxicity, such as a decrease in the growth of plants or a change in the relative abundance of species that are sensitive or insensitive to certain contaminants. Comparative ecological studies using reference areas is another means of assessing contaminant effects.

9.2.4.2 Task 5: Exposure Assessment and Pathways Model

The objective of this task is to assess the physical and biological exposure pathways of the contaminants. Each pathway will be described in terms of the chemical and/or radionuclide releases and concentrations, environmental media, and potential target taxa. The exposure assessment process will include the following three subtasks: (1) identification of exposure routes and pathways, (2) determination of exposure points and concentrations, and (3) estimation of chemical or radionuclide intake/dose for receptors. Each of these subtasks is described below.

Exposure Pathways

The purpose of this subtask is to qualitatively identify the actual or potential pathways by which various biological receptors at or near OU4 might be exposed to site-related chemicals or radionuclides. The exposure pathways analysis will address the following five elements:

1. Chemical/radionuclide source
2. Mechanism of release to the environment
3. Environmental transport medium (e.g., soil, water, air) for the released chemical/radionuclide
4. Point of potential biological contact (exposure point) with the contaminated medium
5. Biological uptake mechanism and absorption (dose) at the point of exposure.

All five elements must be present for an exposure pathway to be complete. Exposure pathways will be modeled, and the models will be evaluated using toxicity tests and actual contaminant concentrations. These results will be used to evaluate the need for additional ecotoxicological investigations in Task 8.

Determination of Exposure Points and Concentrations

Exposure points are locations where receptor species may contact COCs. Preliminary identification of exposure points will result from the pathways modeling described above. Fate and transport modeling will then be used to assess exposures for target species. A preliminary characterization of the nature and extent of contamination in abiotic media (air, soils, surface water, and ground water) is presented in Section 2.0 of this Work Plan. Phase I data, where available, will be summarized and used in characterizing source areas and release characteristics at the site. The exact exposure points can be expected to vary, depending on both the contaminant and the target species under consideration. The exposure assessment will provide information on the following:

- Major routes of exposure
- Organisms that are actually or potentially exposed to contaminants from OU4
- Concentrations of each contaminant to which organisms are actually or potentially exposed
- Frequency and duration of exposure
- Seasonal and climatic variations in conditions that may affect exposure
- Site-specific geophysical, physical, and chemical conditions that may affect exposure.

This approach can provide the average and most probable potential maximum concentrations of chemicals at the exposure points and allow evaluation of the likelihood of maximum effect on target taxa.

Estimation of Chemical Intake by Target Species

This subtask will focus on evaluation of the routes of contaminant uptake by target species. Potential mechanisms of uptake include direct routes (e.g. root uptake, inhalation, ingestion of contaminated media, or dermal contact) and indirect routes (e.g. foliar deposition or ingestion of prey species that have been contaminated). The actual absorption rates and metabolic fate of a contaminant is also important in determining ultimate doses. Contaminants that tend to bioaccumulate can result in exposure concentrations greater than those from the environmental media alone. Exposures will be evaluated according to published bioconcentration factors (BCFs) and site-specific data when available. The amounts of chemical and radiological uptake will be estimated using site-specific analytical data and forthcoming guidance from EPA's *Wildlife Exposure Factors Handbook* (to be published in 1991). A pathways model will be used to establish relationships between contaminant concentrations in different media and concentrations known to cause adverse effects.

Direct measurement of contaminant loads will be conducted in tissue analysis activities in Task 9. These data will be used to assess uncertainty in the pathways model and thus aid in the integration of the overall studies at the RFP with other OU investigations.

9.2.4.3 Task 6: Preliminary Contamination Risk Characterization

Contamination risk characterization entails integration of exposure concentrations and reasonable assumptions with the information developed during the exposure and toxicity assessments. This is done to characterize current and potential adverse biological effects (e.g., death, diminished reproductive success or productivity, reduced population levels) posed by OU4 contaminants. The potential impacts from all exposure routes (root uptake, foliar deposition, inhalation, ingestion, and dermal contact) and all media (air, soil, ground water, and surface water/sediment) will be included in this evaluation, as appropriate, according to EPA guidance (U.S. EPA, 1989f).

Characterization of adverse effects on receptor species and populations is generally more qualitative than characterization of human health risks because the toxic effects of most chemicals, and their environmental fates and interactions, have not been well characterized for natural and disturbed ecosystems. Criteria that are suitable and applicable for evaluation of ecological effects are generally limited. EPA Ambient Water Quality Criteria (AWQC) and Maximum Allowable Tissue Concentrations (MATC) are the most readily available criteria. Criteria set forth in federal and Colorado laws and regulations pertaining to preservation and protection of natural resources can also be used where available such as the Endangered Species Act. Criteria may also be derived from



information developed for use under other environmental statutes, such as the Toxic Substances Control Act (TSCA) or the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

In accordance with EPA guidance (U.S. EPA 1989d and 1989e), priority will be placed on determining the adverse effects of chemicals at the ecosystem, habitat, and population levels rather than effects on individual organisms. These adverse effects can be estimated using a "weight of evidence" approach using several procedures: comparing contaminant intake to acceptable values, exposure point or dose estimates to toxicity value in the literature, or ecological endpoints or biomarkers in target taxa within OU4 to reference populations. Where specific information is available in the published literature, a more quantitative evaluation of effects will be made using the site-specific pathways model. This approach is in agreement with EPA guidance (U.S. EPA, 1989c).

The assessment characterization may also include evaluating the results of direct toxicity tests at OU4 or results at other OUs, and the bioaccumulation value. Quantitative estimates of effects may be calculated by converting the conceptual model into logic diagrams and assigning probabilities to the steps in the model. The method for determining contamination effects will depend on site specific information. The characterization will separate effects, where possible, into organic, inorganic, and radionuclide categories based on the contaminant of concern properties and toxicities.

9.2.4.4 Task 7: Uncertainty Analysis

The process of assessing ecological effects is one of estimation under conditions of uncertainty. The estimates are dependent on numerous assumptions and other sources of uncertainty such as measurement variability and natural ecosystem processes. To address uncertainties, the OU4 EE will present each conclusion, along with the interpretations or data that support and fail to support the conclusion, and the uncertainty accompanying the conclusion. There will be a need to address the level of confidence by quantifying the results of the assessment. Factors that limit or prevent development of definitive conclusions will also be discussed. In summarizing the assessment data, the following sources of uncertainty and limitations will be specified:

- Inherent variability of measurements and of the ecological parameter and population being assessed
- Parameter values from literature and extrapolation to field situation in unmanaged ecosystems

- Variance estimates for all statistics
- Assumptions and the range of conditions underlying use of statistics and models
- Narrative explanations of other sources of potential error.

These variances and errors can be reduced by increased precision of measurements or taking additional samples as well as the validation and calibration of the pathways models used. Other types of variability, such as effects of low concentration of contaminants, cannot be reduced by increased sample collection or measurements. The uncertainty analysis may identify additional data needs.

9.2.5 Task 8: Final Planning for Field Investigation

Task 8 will include planning for tissue analysis studies and any additional ecotoxicological studies needed to assess the adverse effects of COCs on receptor species. Planning for the Task 8 field investigations will begin after COCs and target species have been selected in Task 2. Final planning in Task 8 will consider new data generated during other activities of the Phase I RFI/RI in order to revise field sampling activities. Such data may reveal previously unknown contaminants or the need for additional soil or sediment sampling to complement sampling performed in association with other RFI/RI activities. For example, additional sampling may be required to determine levels of a target analyte in soils at reference areas in which vegetation is to be sampled for tissue analysis. Methods for any additional sampling will be consistent with those used in other Phase I RFI/RI activities.

The need for selecting and measuring additional ecotoxicological or assessment endpoints in Task 8 will be evaluated on the basis of the pathways analyses and published information on direct toxic effects. Data from Task 3 and abiotic sampling programs may also reveal the need for further ecological testing, or to reevaluate COCs and biotic tissue needed for analysis. For example, results of the surficial soil sampling in and around the SEP may indicate the need for assessment of soil microbial function in areas of depauperate vegetation.

Selection of field methodologies will be based on a review of available scientific literature which provides quantitative data for the species of concern or similar test species. Analysis of population, habitat, or ecosystem changes will be based on species or habitats that represent broad components of the ecosystem or that are especially sensitive to the contaminant(s). In order to select methodologies for the ecotoxicological field sampling program, the biological response under consideration

and the proposed methodology should satisfy program DQOs as well as the following more specific criteria:

- The methodology and measurement endpoint must be appropriate to the exposure pathway.
- The endpoint response to the contaminant is well defined, easily identifiable, and predictable.
- The contaminant is known to cause the biological response in laboratory experiments or experiments with free-ranging organisms.
- The available sample size is large enough to make the measurement useful.

Additional tissue analyses will be evaluated for terrestrial species from OU4 and reference areas based on the Task 3 investigations.

Prior to conducting Task 8 studies, the FSP will be refined to address the proposed methodologies. More specific DQOs will be formulated on the basis of the proposed methodologies and will address the following:

- Number and types of analyses
- Species, locations, and tissues to be sampled
- Number of samples collected
- Detection limits for contaminants
- Acceptable margin of error in analyzing results.

Selection of the species and specific tissues for analysis will be based on a preliminary evaluation of site-specific food webs, potential contaminant transport pathways, and the potential for accumulation in specific organs or tissues. The decision process for conducting tissue analyses or effects in target taxa is presented in Figure 9-4. Tissue sampling will be conducted for only the COCs that bioaccumulate. Whole-body burdens or individual tissues may be analyzed, depending on which portions are consumed by organisms in higher trophic levels. Suitability of a species for tissue sampling will depend on its position in the food web and its abundance at the site.

To the extent possible, tissue samples will be collected simultaneously with other biological and environmental media samples collected during other Phase I RFI/RI sampling activities. This will allow for determination of site-specific BCFs, which will then be incorporated into the exposure assessment for use in calibrating/validating the pathways model. Where BCFs cannot be determined, published or predicted BCF values will be used in the pathways model to assess potential impacts.

Where ARARs (i.e., acceptable levels in receptor species or prey species) are established, tissue sampling must be conducted only at the study area and not in reference areas. Where no pertinent ARARs exist, tissue sampling may include suitable reference areas. The decision process for the use of reference areas in tissue sampling is illustrated in Figure 9-5. Use of statistical tests will be consistent with DQOs and quality assurance provisions of the QAPjP.

Additional ecotoxicological studies indicated from results of Tasks 4 and 5 may include in-situ (in-field) toxicity testing and/or further laboratory toxicity testing. These tests can be used to isolate specific contaminants or sources. Selection of a particular methodology is generally based on the capability of the method to demonstrate a measurable biological response to the selected contaminant(s) of concern on a potential target species.

9.2.6 Task 9: Ecotoxicological Investigations

The Task 9 ecotoxicological investigation will consist primarily of collection of additional samples for tissue analysis and additional measurements for biotic impact effects as endpoints or biomarkers on ecosystem processes or population parameters in the field. Analyses of tissue contaminant concentrations will provide data for evaluation of the relationship between environmental concentrations and toxicity from contaminant loads predicted by pathway and food web models.

The revised FSP developed in Task 8 will be executed in Task 9. SOPs and analytical protocols will be closely adhered to. Reference areas will be sampled in parallel to study areas to help ensure comparability of data, if determined to be necessary. Results of Task 9 activities may be used to revise contamination assessment and pathways models. Further sampling will be performed if necessary. Data validation will be an integral part of the sampling conducted during this task.

9.2.7 Task 10: Environmental Evaluation Report

Task 10 will include the final contaminant risk assessment and summarization of information and production of an environmental evaluation report as part of the RFI/RI report. The Environmental Evaluation Report (EER) will be prepared in a clear and concise manner to present study results and interpretation. All relevant data from the EE, in addition to relevant Phase I RFI/RI data, will be integrated and evaluated in the characterization of potential environmental impacts. A proposed outline for the EER is presented in Table 9.7

9.2.7.1 Perform Final Contaminant Risk Assessment

Prior to writing the report, a final contaminant risk assessment verification will be conducted using the information and data collected in the field and ecotoxicological investigation in Tasks 3 through 9. This verification of the Task 6 assessment will incorporate site toxicity values and tissue concentrations in pathway models. Ecological endpoints, population, and ecosystem effects will be characterized using a weigh of evidence approach which considers all lines of evidence in characterization. The verification process may affect the uncertainty analysis and reduce error or raise the level of confidence in the EE. Additional data needs or studies beyond the scope of the EE may be suggested.

An initial draft report will be written in which the following topics will be covered:

- Objectives
- Scope of Investigation
- Site Description
- Contaminants of Concern and Target Species
- Contaminant Sources and Releases
- Exposure Characterization
- Impact Characterization
- Remediation Criteria
- Conclusions and Limitations.

A proposed outline to be followed in preparing the EER is presented in Table 9.7. The EER will be presented and written for use by a diverse group such as specialists, agency personnel, and the general public. An Executive summary will present the basic information in each section of the assessment, how this information supports the characterization, and the general conclusion reached in the EE.

9.2.7.2 Remediation Criteria

Remediation criteria protective of Rocky Flats biota will be developed in Task 10 on the basis of the results of the food web analyses, pathways model, and exposure assessments. Remediation criteria will be developed for contaminants for which a significant ecological impact is detected or for which a significant risk exists. Criteria will address remediation of the contaminant source so that remaining environmental concentrations and forms do not pose a threat to target taxa. "Acceptable" environmental concentrations will be estimated using exposure assessments to calculate contaminant concentrations in abiotic media below which the ecotoxicological effect is not expected to occur. The acceptable (no effects) criteria levels will be used in conjunction with ARARs to

evaluate potential adverse effects on biota as appropriate for the EE portion of the Phase I RFI/RI. This approach will be integrated with the baseline human health risk assessment process and will assist in development of potential remediation criteria.

9.3 FIELD SAMPLING PLAN

Field sampling activities will be conducted in Tasks 3 and 9 of the EE. Task 3 field sampling will include the following:

- Confirmation of habitats and vegetation mapping units at OU4
- Selection of reference area, if necessary
- Characterization of biota present at OU4 (and reference areas, if appropriate).

Planning for the Tasks 8 and 9 tissue analysis program was begun and will continue in Task 2 so that samples collected in the Task 3 field inventory can be used wherever possible (i.e., where COCs have been defined and field sampling protocols have been developed). Final determination of the need for additional ecotoxicological studies (e.g., reproductive success, population studies, or enzyme analyses) will be made after completion of the contamination impact assessment.

The FSP is provisional and will be periodically revised as appropriate. The Task 3 sampling plan is largely complete but may be modified in order to better coordinate with the sampling programs for the OU4 RFI/RI or other operable units. The Task 8 FSP will be designed in greater detail after completion and verification of COCs and target species, preliminary determination of food webs, and contamination source-receptor pathways. In addition, results of Task 8 planning may include plans for additional soil or sediment sampling in study or reference areas. Determination of this need will follow from results of the soil sampling described in Section 7.0. This FSP was prepared in accordance with SOP 5.13 - Development of Field Sampling Plans. All ecological data and sample collection will follow the procedures provided in the Ecology SOP (Volume V) (EG&G, 1991n), with appropriate site specific addenda as needed.

9.3.1 Site Description

OU4 encompasses the Solar Ponds and their area of influence, the study area as indicated in Section 9.2 and on Figure 9-2. The Solar Ponds have historically been the recipients of industrial and hazardous waste stream products produced at the Rocky Flats Plant. Five ponds are presently in existence and Pond 207-A is the largest pond. Ponds 207-B North, Center, and South are smaller,

ponds to the east of Pond 207-A. Pond 207-C is approximately equal in size to the B series ponds and lies to the west of Pond 207-A.

9.3.1.1 Study Site Detail

Although the ponds were lined, it is known that some leakage into the ground around and underneath the ponds has occurred. The water collected in the ITS is pumped back into the ponds. As noted previously, overlap with other operable units is expected and coordination with them for the exact extent of the OU4 study area boundaries will be necessary. Tentative study area boundaries for OU4 are the perimeter access road around the security fenced area to the north of the ponds, the area around and east of the ponds to an access road, west to the dirt road just west of Pond 207-C, and south to the paved road to the south of the ponds (see Figure 9-6). The entire OU4 and study area has been disturbed by grading and facilities construction and drainage control. Plants have subsequently revegetated some areas by planned seeding or natural invasion, and some animals have become reestablished. Ponds may be dewatered by the time of implementation of this EEWP and other interim closure activities started.

9.3.1.2 Reference Site Detail

The reference site for OU4 may be located in the buffer zone to the north of the Rocky Flats Plant. The exact location will need to be determined based on the following criteria:

- Habitat Type -- The Solar Ponds and part of the surrounding study area are within a restricted access area. In those sections, wildlife is restricted to those which can penetrate the security fence. The vegetation has been disturbed by the building of the ponds, the ITS, and surrounding buildings. The reference site should have a natural seep similar to that immediately below (to the north of) the ponds.
- Habitat Size -- The actual size of available habitats within the study area is limited to the slopes to the north of the ponds and the drainage to the south of the ponds at the headwaters to South Walnut Creek. When the exact extent of the study area is determined during Task 1 of the EE, habitats within the reference area should correspond in size and disturbance to account for the edge effect.
- Slope and Aspect -- The reference site will need to have a slope with a north aspect at a degree of slope within about 25° of the compass direction (aspect) of the slope below the ponds where the ITS is located.
- Soil Type -- General soil type or types should be similar and take into account disturbance, fill materials, and loss of topsoil where appropriate.

Notable differences between study and reference site must be reported.

All of these criteria for a reference area, especially an industrially disturbed and protected area, will probably not be met. A reference area for this operable unit may not be necessary and should be reevaluated during implementation of the EE.

9.3.2 Objectives

Objectives for the field sampling plan are:

- Collect site specific data on biota and important abiotic parameters
- Provide input into the conceptual model and exposure analysis
- Measure concentrations of contaminants in terrestrial organisms
- Measure indicators of impacts or stresses (ecological endpoints).

COCs and Ecological Target Taxa

The Solar Ponds received nitrates, radionuclides, metals, and other process wastes produced at the Rocky Flats Plant and are expected to have high contamination of these analytes. A preliminary list of COCs is provided in Table 9-4 although this list is expected to be revised or expanded.

Target taxa (receptors of concern) will be limited to plant species, herbivorous small mammals, and arthropods. They are limited to producers and primary consumers. Secondary consumers (predatory birds, mammals) are not of concern because too little of their diet is composed of material from the OU4 study area. The potential target taxa (receptors of concern) are given in Table 9-6.

DQOs for Each Activity

The detailed DQOs for the surveying and sampling of target taxa, handling of samples and analysis, and compiling and reporting data are still to be developed.

Habitat and Taxa Specific Sampling

The major community habitat type found in the study area is the disturbance/ barren land. A minor community within this is the cheat grass/weedy forbs community type. A second major type is the mixed grassland complex. A minor community within the grassland is comprised of two short marsh/wet meadow type areas (see Section 9.1.3.1). None of these communities have natural, undisturbed soils or vegetation.

9.3.3 Habitat and Taxa Specific Sampling

The disturbed habitats at OU4 are small and limited in the number of taxa and trophic levels present. Aquatic habitats are lacking, and the ponds in their present condition support little or no biota other than algae and bacteria. The terrestrial sampling will be limited to vegetation, small mammals, and arthropods. Coyotes and fox, the large mammals probably present in the study area, and birds, including raptors, would be only occasional users due to their high mobility and the condition of the small and highly disturbed study area. Therefore, they were not included in the sampling program. Sampling of reptiles and amphibians for tissue analysis is not anticipated.

9.3.3.1 Terrestrial Sampling

The objective of data and sample collection in terrestrial habitats is to gather data for construction of food web and exposure pathways models. Relative abundance and distribution will be assessed for all relevant major groups of terrestrial organisms. Sampling locations for small mammals and terrestrial arthropods will coincide with vegetation sampling locations. Collection of samples for tissue analysis will include small mammals, arthropods, and vegetation. Preliminary sampling locations are shown in Figure 9-6.

Vegetation

Objectives

Data and sample collection will follow procedures described in SOP 5.10. Spring and late summer data will be collected, and tissues will be collected for analysis at a time to be determined later. Data collected will be used to assess the following objectives:

- Total plant cover
- Cover by perennial grasses, annual grasses, perennial forbs, and annual or biennial forbs
- Cover by individual species
- Richness (number of species)
- Production (standing biomass in grams per square meter [g/m²] and pounds per acre [lbs/acre])
- Height (in centimeters).

Sample Locations

Study site sample locations were determined on the basis of vegetative community availability and are depicted in Figure 9-6. These locations are preliminary and will have a final determination during the initiation of work. Potential locations in adjacent OUs are identified, but are not included in the present sampling scheme. Reference site sampling locations will also be defined at that time if a reference site is determined to be necessary.

Collection Methods

Collection methods for terrestrial plant sampling will follow the procedures outlined in Section 6.0 of SOP 5.10. The limited amount of vegetation and total lack of any naturally occurring vegetation restricts the quantitative surveys to the use of the production plots method only. Sample size adequacy in cover and biomass surveys will be determined using Cochran's formula (Cochran, 1977).

The qualitative sampling method will involve compiling a comprehensive species list for each community type by traversing the entire study area at least monthly throughout the growing season, and describing abiotic features such as substrate, topography, and soil moisture that could influence composition and structure. The releve-method (also known as the sample-stand or species-list method) will be used since the area is too limited for cover transects (Section 6.3.1 SOP 5.10).

Collection of plant tissue for laboratory analysis will be conducted independent of the community surveys and biomass production and will follow Section 6.4 of SOP 5.10. Only aboveground biomass will be collected during Task 3 collection; if plant and soil results dictate, root collections may be done during Task 9. Collection locations will be in the same location as the releve-method surveys on the study area and from reference areas, if appropriate. Tissue samples will consist of five samples per survey in the weedy area, up to ten samples per survey in the grassland area and one sample in each of the seep areas. Samples will be selected randomly within the survey areas. The samples will consist of aboveground biomass from 0.5 m² plots. The plant tissue will be separated into species types for species of greater than 25% of total plant cover and the remaining tissue will be composited.

Sampling Intensity

Sample size will be determined at the time of sampling with species area curve plots and sample adequacy calculations. Because sample frequency is dependant on the climate (temperatures and

precipitation) of the year the sampling is done, exact sampling dates will be determined during the sampling season. Two sampling periods during the late spring/early summer and late summer/early fall are recommended for the Task 3 sampling period. The Task 9 sampling period, if needed, will occur immediately after Task 3 sample results are analyzed for completeness for modeling. It is critical that this occur as quickly as possible before inclement weather makes the Task 9 sampling impossible or inaccurate. Otherwise, it should be postponed to the following growing season.

QA/QC Sample Schedule

Quality assurance/quality control will follow procedures defined in SOP 5.0. Any variance from SOP will be described and the reason explained. Quality assurance/quality control for tissue sample collection should be accomplished by collection of collocated duplicates according to the Quality Assurance Project Plan (QAPP).

Sample Handling and Preservation

Biomass samples will be separated by species into labeled paper bags and oven-dried in the bag (104°C for 24 hours) then weighted. Clipped material will be maintained in the marked paper bags until the conclusion of the study. Samples collected for tissue analysis will follow the sample preparation and packaging specified by the laboratory protocols for the selected analytes and should be generally consistent with SOP 1.13.

Small Mammals

Objectives

Small mammal populations will be surveyed to determine habitat use and relative abundance. The results will be used to select species to be collected for tissue analysis. The data will be used in development of pathways models and the exposure assessment. For community evaluation, endpoints will include:

- Richness (number of species)
- Abundance (number per trapping period) by species
- Mean weight.

Sample Locations

Sampling locations will coincide with vegetation sampling locations in areas of suspected contamination and in reference areas, where appropriate.

Collection Methods

Small mammals will be collected using the live-trapping techniques described in SOP 5.6. Trap grids or lines (size and shape to be field determined) will be set for four consecutive nights, as described in SOP 5.6.

Tissue samples will be collected, if determined necessary, from grids corresponding to vegetation transects in areas of known contamination. To collect individuals for tissue analysis, each individual of the designated target taxon will be randomly assigned to a particular analytical suite. Collection will continue until all of the required sample quantity is obtained. If composite samples are required, each individual will be randomly assigned to a sample, and collection will continue until six samples of the appropriate quantity are obtained. If multiple trap-nights are required to obtain adequate sample quantity, individuals will be frozen as soon as possible, but within four hours of collection. Tissue sampling will occur in late summer or fall after the conclusion of the live-trapping program. Only adult males and non-lactating females mammals will be collected. Reference areas may be used in the tissue sampling section of the study, if necessary and appropriate.

Sampling Intensity

Each sampling suite will be run for a least four consecutive nights. Live trapping will be conducted in the spring (April - May) and early fall (September - October) providing that the population will support this intensity.

QA/QC Sample Schedule

Quality assurance/quality control will following procedures defined in SOP 5.0. Any variance from SOP will be described and the reason explained. Special attention will be given to minimizing chance of harm to the animals not intended for tissue analysis and to avoid injury to the workers from animal bites or scratches.

Sample Handling and Preservation

Animals collected for tissue analysis will be sacrificed by placing into a sealed container with cotton saturated in Metaflane, inducing hypothermia, or cervical separation. The dead animal will be placed in a glass sample container in a cooler with Blue or dry ice for up to four hours. After four hours, the samples must be shipped to the analytical laboratory or place in a freezer overnight or until shipped. Labeling, handling, and shipping of small mammals for laboratory analysis should be

generally consistent with SOP 1.13. Samples collected for tissue analysis must follow the sample preparation and packaging specified by the laboratory protocols for the selected analytes.

Arthropods

Objectives

Terrestrial arthropods (e.g., insects, spiders, ticks) will be surveyed for relative abundance, and composite samples of selected taxa will be collected for tissue analysis. Assessment of community composition will include evaluation of the following endpoints:

- Richness (number of species collected from a given transect)
- Biomass (g/m² of selected taxa collected from transect).

Sample Locations

Sampling locations will coincide with vegetation sampling locations in OU4, other areas of known contamination, and reference areas.

Collection Methods

Collection of survey data will involve use of sweep nets and pitfall traps, in accordance with SOP 5.9. Coleopterans (beetles) will be emphasized in collection of specimens for tissue analysis. In grasslands, this group is primarily ground dwelling, and relatively large numbers can be obtained. Pitfall traps will be used to collect specimens for tissue analysis. For tissue analysis, six samples will be selected at random from the ten collected along the vegetation transect.

The Berlese Funnel Analyses (Section 6.2.6 SOP 5.9) method to collect soil arthropods may be used during the Task 9 sampling period if high contamination of surface to 18 inch depth of soil is found during soil sampling.

Sampling Intensity

Sweep-netting will follow the full length of the small vegetation community present with care to collect from the area uniformly (both vertically and horizontally). One pitfall trap will be located every 5 meters along a line parallel to the long axis of the vegetation habitat. Traps will be checked after dawn, at mid-day, and before dusk for a minimum of three consecutive days.

QA/QC Sample Schedule

Quality assurance/quality control will follow procedures defined in SOP 5.0. Any variance from SOP will be described and the reason explained. Special care in the handling of killing jars and other containers with potentially hazardous materials will be specified.

Sample Handling and Preservation

Netted material collected during the sweep-netting method will be aggregated at the end of each transect and enclosed in a killing jar containing ethyl acetate.

Samples obtained will be placed in a glass jar or glassine envelope for later identification and enumeration, as appropriate. Organisms to be preserved as voucher specimens will be pinned or placed in ethyl alcohol or 5% buffered formalin, as appropriate.

Samples collected for tissue analysis will follow the sample preparation and packaging specified by the laboratory protocols for the selected analytes and should be generally consistent with SOP 1.13.

Terrestrial Sampling Matrix

A complete table will be constructed that contains sample locations, objectives (tissue, quantitative or qualitative community analysis), methods, and sampling dates for each taxon when these facts are fully determined. A matrix will be developed following protocol in the Ecology SOP, Volume V (EG&G, 1991M) for each taxon.

9.4 SCHEDULE

An approximate schedule for conducting and completion of the work outlined in this EEWP is presented in Figure 9-7. This schedule is also integrated with the flow diagram presented in Figure 9-1 on the interrelationship of the tasks and subtasks. Decision points in this schedule for the timing of, and necessity for, a task have not been determined. However, the process for these decisions is included in the EEWP.

Seasonal changes and weather patterns profoundly affect the required timing and results of ecological field sampling. The general timing of field activities will be subject to change in relationship to the seasons. The exact timing of the field sampling activities are dependent on rainfall and temperature during the growing season and the preceding winter's precipitation. To the extent possible, this timing will be adjusted to take into account these weather related factors.

Table 9-1: Summary of Potential Metal and Inorganic Contamination of Solar Evaporation Ponds

Parameters	Maximum Value Reported (ug/l)	Location	Site-wide Background (ug/l)	Federal Standards		State Standards		
				AWQC for Protection of Aquatic Life (ug/l)		MCL	Biological Parameters of Aquatic Life (ug/l)	
				Acute	Chronic		Acute	Chronic
METALS								
Aluminum	2,640	207-A	60,423			0.05	950	150
Arsenic	150	207-A	1,030			0.05		
Barium	220	207-B North						
Beryllium	60	207-C	11	130	5.3			
Boron	14,000	207-A						
Cadmium	150	207-A						
Calcium	290,000	207-B North	43,360					
Cesium	350	207-B Center						
Chromium	167,000	207-A	275	1700-III	210-III	0.05	TVS-III	TVS-III
Cobalt	500	207-A	489					
Copper	1,800	207-A	607	18	12		TVS	TVS
Iron	8,000	207-A	87,147			0.3		300
Lead	3.5	207-B North	516	82	3.2	0.5	TVS	TVS
Lithium	6,000	207-B North	100					
Magnesium	120,000	207-B North	8,938					
Manganese	22	207-B North	1,965			0.5		50
Mercury	0.2	207-A	1.4	2.4	0.012	0.002		
Molybdenum	37	207-B Center						
Nickel	2,000	207-A	646	1,400	160	TVS	TVS	TVS
Phosphorous	8,180	207-A						
Potassium	14,300,000	207-A	1,020					
Selenium	24	207-B North	25	260	36	0.01	135	17
Silicon	5,600	207-B North						
Silver	15	207-B Center						
Sodium	42,900,000	207-A	23,100					
Strontium	21,000	207-B North	1,460					
Tritium	41	207-B Center						
Tin	13,000	207-A	969					
Vanadium	200	207-A						
Zinc	780	207-A	376	120	110	5,000	TVS	TVS
Zirconium	4.1	207-B Center						

Table 9-1: Summary of Potential Metal and Inorganic Contamination of Solar Evaporation Ponds

Parameters	Maximum Value Reported (ug/l)	Location	Site-wide Background (ug/l)	Federal Standards		State Standards			
				AWQC for Protection of Aquatic Life (ug/l)		MCL	Biological Parameters of Aquatic Life (ug/l)		Stream Segment Standard (ug/l)
				Acute	Chronic		Acute	Chronic	
INORGANICS/ANIONS									
Cyanide	8.5	207-C	45.2	22	5.2	10,000	5	5	5
Nitrate/Nitrite	724,000	ITS	20,000						250 mg/l
Nitrate as N	21,400	207-C							
pH	11.3	207-C							

Table 9-2: Summary of Potential Radionuclide Contamination of Solar Evaporation Ponds

Analyte	Maximum Value Reported (pCi/l)	Location	Site-wide Background of Surface Water (pCi/l)	Federal Standards	State Stream Classification Standards	
				SDWA Maximum Contaminant Level	Basin Table D Radionuclide Standards	Table 2- Radionuclide Standard for S. Walnut Creek
Gross Alpha	80,000	207-A	117.43	15 pCi/l		11 pCi/l
Gross Beta	44,000	207-C	163.20	4 mrem/yr		9 pCi/l
Plutonium-239	2,100	207-C	1.46		15 pCi/l	0.05 pCi/l
Americium-241	2,900	207-C	0.18		30 pCi/l	0.05 pCi/l
Tritium	6,400	207-C	2,022.45		20,000 pCi/l	500 pCi/l
Uranium	40,000	207-C				
Uranium-233 + 234	20,000	207-A	1.10			10 pCi/l
Uranium 238	28,000	207-A	0.19			10 pCi/l

Table 9-3: Summary of Potential Organic Contamination of Solar Evaporation Ponds

Analyte	Maximum Value Reported (ug/l)	Location	Site-wide Surface water Background (ug/l)	Federal Standards				
				CWA AWQC for Protection of Aquatic Life (mg/l)		SDWA MCL (ug/l)	CWA Water Quality Criteria for Protection of Human Health (ug/l)	
				Acute	Chronic		Water and Fish	Fish Consumption Only
SEMIVOLATILE ORGANICS								
Bis(2-ethylhexyl) phthalate	24 (B)	ITS	detection level					
Di-n-butyl phthalate	4 (BJ)	ITS	detection level					
Diethyl phthalate	4 (J)	ITS	detection level					
Pentachlorophenol	20 (J)	ITS	detection level					
VOLATILE ORGANICS								
Acetone	80	ITS	detection level			50		
Carbon tetrachloride	11	ITS	detection level					
Chloroform	2 (J)	ITS	detection level					
Methylene Chloride	5 (B)	ITS	detection level	45	21.9	5		
Trichloroethene	5	ITS	detection level			5	80.7	

Note: These data have not been 100% verified. Validation and QA/QC were not available at print time.

B = compound was found in the blank and in the sample.

J = indicates an estimated value for an analyte that meets the identification criteria but had a result less than the specified detection limit.

TABLE 9.4

PRELIMINARY LIST OF CONTAMINANTS OF CONCERN
FOR OU4 ENVIRONMENTAL EVALUATION

Metals

Beryllium
Chromium
Copper
Nickel
Zinc

Volatile Organics

Trichloroethene

Radionuclides

Gross Alpha
Gross Beta
Plutonium-239
Americium-241
Tritium

Inorganics

Nitrate/Nitrite

Table 9-5: OU4 Contaminants of Concern Selection Matrix

Analyte	*Criterion 1 - Occurrence				**Criterion 2 - Ecotoxicity				**Criterion 3 - Extent of Contamination							Summary of Criteria													
	a	or	b	or	c	or	d	a	or	b	or	c	a	and	b	or	c	OR	d	e	or	f	or	g	1	2	3	COC	
METALS																													
Aluminum	X									X					X										X	X			
Arsenic	X									X					X										X	X			
Barium	X																								X				
Beryllium	X									X					X										X	X			X
Boron	X																								X				
Cadmium	X																								X				
Calcium	X												X												X				
Cesium	X																								X				
Chromium	X									X					X										X	X			X
Cobalt	X												X		X										X	X			X
Copper	X									X					X										X	X			X
Iron	X														X										X				
Lead	X												X		X										X				
Lithium	X																								X				
Magnesium	X												X												X				
Manganese	X														X										X				
Mercury	X									X					X										X				
Molybdenum	X																								X				
Nickel	X									X					X										X	X			X
Phosphorous	X																								X				
Potassium	X												X												X				
Selenium	X									X					X										X				
Silicon	X																								X				
Silver	X																								X				
Sodium	X												X												X				
Strontium	X												X												X				
Tritium	X																								X				
Tin	X												X												X				

Table 9-5: OU4 Contaminants of Concern Selection Matrix

Analyte	*Criterion 1 - Occurrence					**Criterion 2 - Ecotoxicity					**Criterion 3 - Extent of Contamination										Summary of Criteria						
	a	or	b	or	c	d	a	or	b	or	c	a	and	b	or	c	OR	d	and	e	f	or	g	1	2	3	COC
Vanadium	X																							X			
Zinc	X						X					X		X										X	X	X	X
Zirconium	X																							X			
SEMIVOLATILE ORGANICS																											
Bis(2-ethylhexyl) phthalate	X		X									X												X			
Di-n-butyl phthalate	X		X									X												X			
Diethyl phthalate	X		X									X												X			
Pentachlorophenol	X		X									X												X			
VOLATILE ORGANICS																											
Acetone	X		X									X		X										X			X
Carbon tetrachloride	X		X									X												X			
Chloroform	X		X									X												X			
Methylene Chloride	X		X									X												X			
Trichloroethene	X		X				X					X		X										X	X	X	X
RADIONUCLIDES																											
Gross Alpha	X								X			X		X										X	X	X	X
Gross Beta	X								X			X		X										X	X	X	X
Plutonium-239	X								X		X	X		X										X	X	X	X
Americium-241	X								X			X		X										X	X	X	X
Tritium	X						X					X		X										X	X	X	X
Uranium	X																							X			
Uranium-233 + 234	X											X		X										X		X	
Uranium 238	X											X		X										X		X	
INORGANICS																											
Cyanide	X						X		X					X										X	X		X
Nitrate/Nitrite	X								X			X		X										X	X	X	
Nitrate as N	X																							X			

Table 9-5: OU4 Contaminants of Concern Selection Matrix

Analyte	*Criterion 1 - Occurrence				**Criterion 2 - Ecotoxicity				**Criterion 3 - Extent of Contamination							Summary of Criteria							
	a	or	b	or	c	or	d	a	or	b	or	c	OR	d	and	e	or	f	or	g	1	2	3
	*1 a. Existing data								**2 a. Acute or chronic toxicity				***3 a. Above background concentration										
	b. Waste stream characterization								b. Sublethal toxicity				b. Above pertinent ARAR										
	c. Process analysis								c. Bioaccumulates				c. Above risk-based level (level not yet determined)										
	d. Historical data												d. Occurs in >5% of samples (not reviewed)										
													e. Widely distributed (not reviewed)										
													f. Occurs in ecologically sensitive area (not reviewed)										
													g. Occurs in "hot spots" (not reviewed)										

TABLE 9.6

POTENTIAL TARGET TAXA
FOR ASSESSMENT OF ECOLOGICAL IMPACTS AT OU4

Mammals

Deer Mouse
Microtines
Cottontail
Coyote
Fox

Terrestrial Invertebrates

Earthworms
Arthropods

Grasses/Forbs

Smooth brome
Tall wheatgrass
Crested wheatgrass
Sideoats grama
Cattails
Alfalfa

Shrubs

Yucca

Microbial Populations

Entire Population

TABLE 9.7

**PROPOSED ENVIRONMENTAL EVALUATION REPORT OUTLINE
SOLAR EVAPORATION PONDS
OPERABLE UNIT 4**

EXECUTIVE SUMMARY

1.0 INTRODUCTION

- 1.1 Approach and Objectives
- 1.2 Contamination
- 1.3 Scope of the Environmental Evaluation

2.0 SITE DESCRIPTION

- 2.1 Physical Environment
- 2.2 Terrestrial and Aquatic Ecosystems, Habitats
- 2.3 Contaminants of Concern
 - 2.3.1 Sources and Releases
 - 2.3.2 Criteria and Definition

3.0 CONTAMINANT IMPACT ASSESSMENT

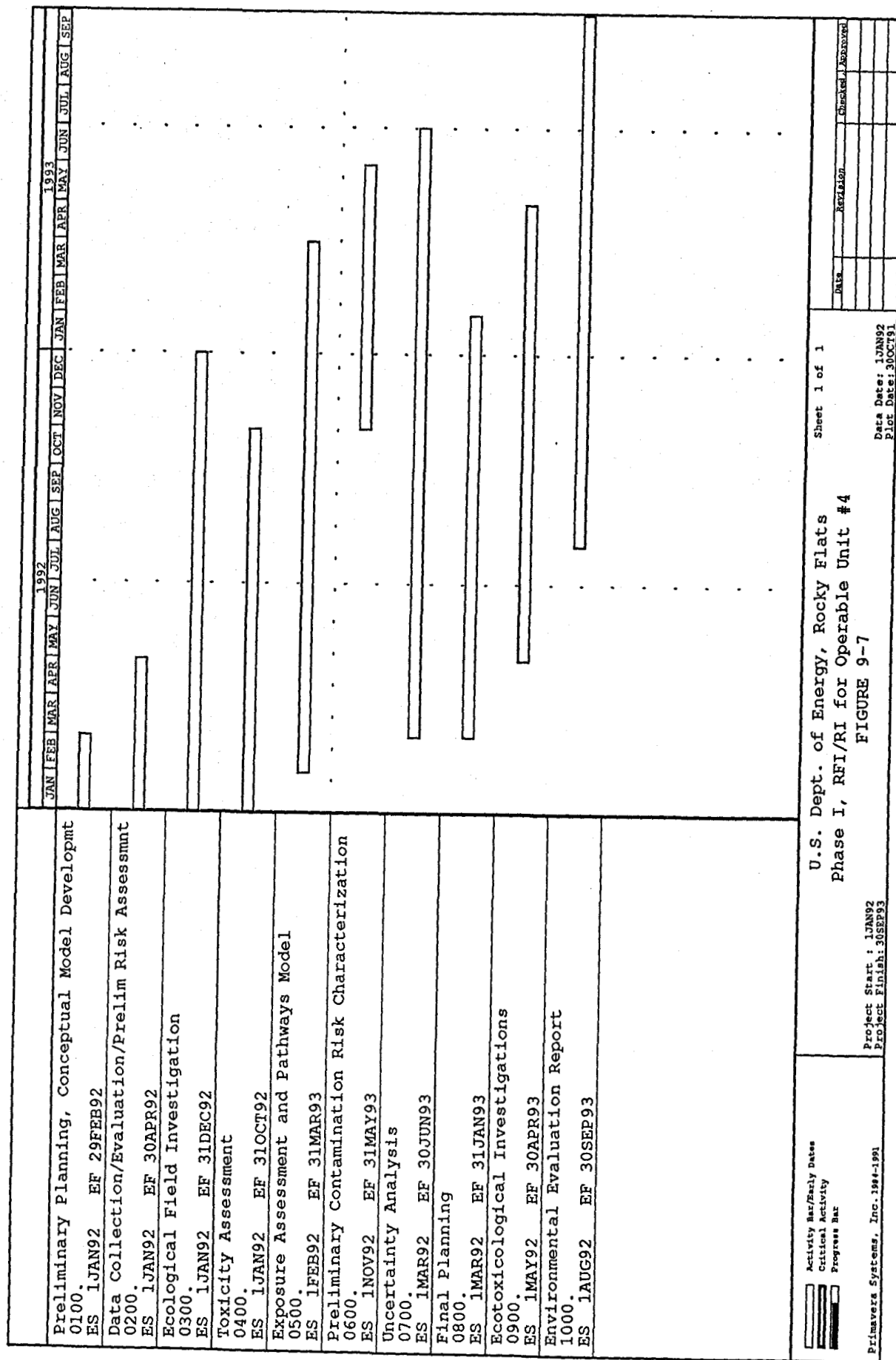
- 3.1 Information and Data Base
 - 3.1.1 Review of Available Information
 - 3.1.2 Ecological Field Investigations and Sampling Results
- 3.2 Toxicity Assessment
- 3.3 Exposure Assessment
 - 3.3.1 Pathway Analysis
 - 3.3.2 Exposure Media
 - 3.3.3 Chemical Fate and Transport
 - 3.3.4 Exposure, Dose Analysis
- 3.4 Effects Characterization

4.0 ENVIRONMENTAL EVALUATION REPORT

- 4.1 Final Risk Characterization
- 4.2 Uncertainty Analysis and Assumptions
- 4.3 Remediation Criteria

5.0 REFERENCES

Preliminary Environmental Evaluation Activity Schedule for OU#4



ENVIRONMENTAL RESTORATION PROGRAM
Phase I RFI/RI Work Plan
for Operable Unit No. 4

Manual: 21100-WP-OU04.1
Section No.: 4.1, Rev. 0, Draft A
Page: 1 of 22
Effective Date:

Approved by:

Manager, Remediation Programs

RFI Project Manager

10.0 QUALITY ASSURANCE ADDENDUM

This section consists of the Quality Assurance Addendum (QAA) for Phase I investigations at Operable Unit No. 4 (OU4), which supplements the "Rocky Flats Plant Site-Wide Quality Assurance Project Plan for CERCLA Remedial Investigation/ Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities" (QAPJP). This QAA establishes the site-specific Quality Assurance (QA) controls applicable to the investigation activities described in the OU4 Work Plan (OU4 WP).

OU4 is one of 16 operable units (OUs) identified for investigations under the Rocky Flats Plant (RFP) Interagency Agreement (IAG). OU4 consists of the Solar Ponds Waste Management Unit, which is considered equivalent to Individual Hazardous Substance Site 101 (IHSS 101). The major features of IHSS include the present Solar Evaporation Ponds, the Original Pond, the Interceptor Trench System (ITS), and areas in the immediate vicinity of the Solar Ponds. The physical setting of OU4 is described in Section 2.0 and illustrated in Figure 2-2.

Phase I of the RFI/RI process typically involves characterization of the site physical features and definition of contaminant sources. In addition to this, groundwater monitoring wells will be installed upgradient of the IHSS to assess potential contamination related to the Solar Ponds and to differentiate contamination from other potential sources located upgradient of the site. This is being done in accordance with RCRA guidance. The OU4 WP has been prepared in accordance with the Federal and State of Colorado regulations and guidance documents identified in the Introduction (Section 1.0).

10.1 ORGANIZATION AND RESPONSIBILITIES

The overall organization of EG&G Rocky Flats and the Environmental Management Department (EMD) and divisions involved in Environmental Restoration (ER) Program activities is shown in Figures 1-1, 1-

2, and 1-3 of Section 1.0 of the QAPjP. Individual responsibilities are also described in Section 1.0 of the (QAPjP).

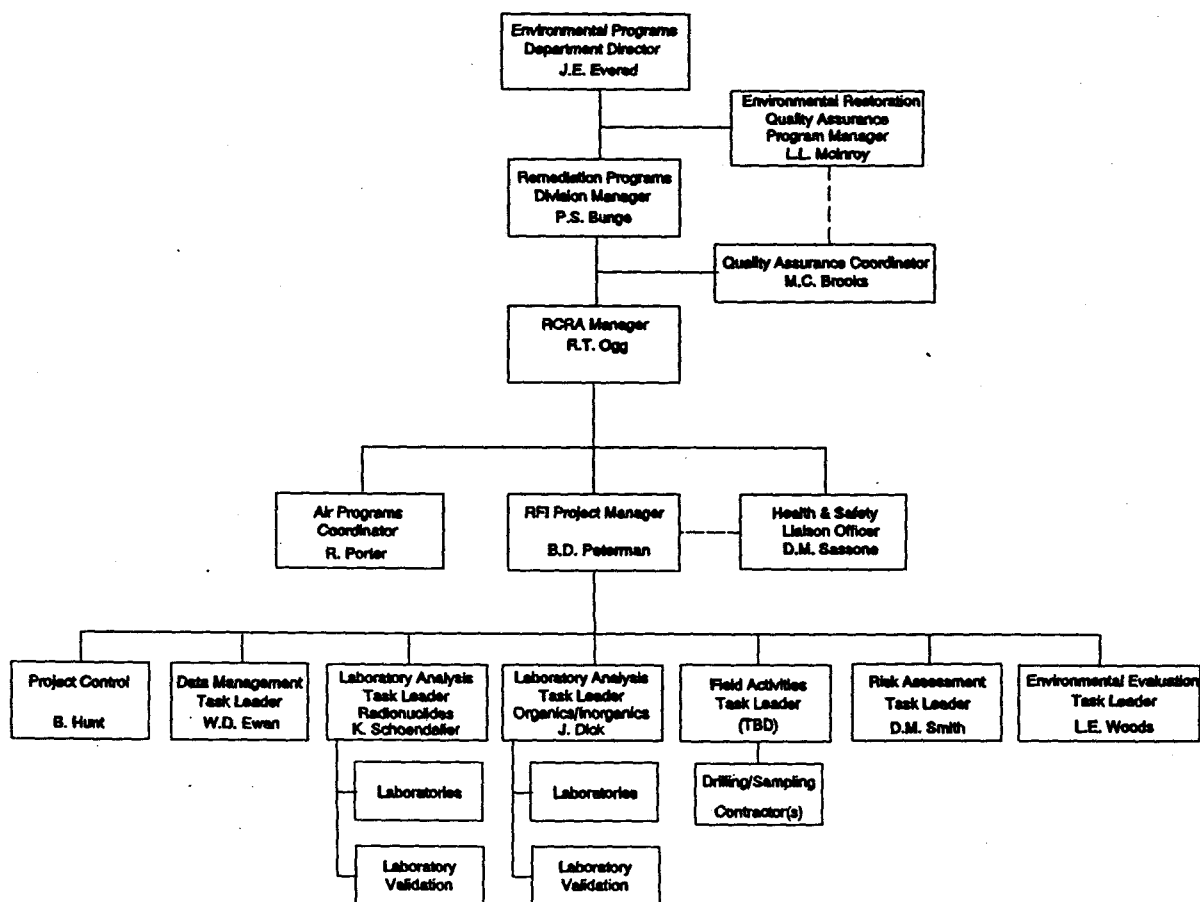
Contractors will be tasked by EG&G Rocky Flats to implement the field activities outlined in the OU4 WP. The specific EMD personnel who will interface with the Contractors and who will provide technical direction are shown in Figure 10-1.

10.2 QUALITY ASSURANCE PROGRAM

The QAPjP was written to address QA controls and requirements for implementing IAG-related activities. The content of the QAPjP was driven by Department of Energy (DOE) RFP Standard Operating Procedure (SOP) 5700.6B, which requires a QA program to be implemented for all RFP activities. This program is required to be developed based on American Society of Mechanical Engineers (ASME) NQA-1, "Quality Assurance Requirements for Nuclear Facilities," as well as the IAG, which specifies that a QAPjP for IAG-related activities be developed in accordance with the Environmental Protection Agency (EPA) QAMS-005/80, "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans." The 18-element format of NQA-1 was selected as the basis for both the QAPjP and subsequent QAAs with the applicable elements of QAMS-005/80 incorporated where appropriate. Figure 2-1 of the QAPjP illustrates where the 16 QA elements of QAMS-005/80 are integrated into the QAPjP and also into this QAA. Section 2.0 of the QAPjP also identifies other DOE Orders and QA requirements documents to which the QAPjP and this QAA are responsive.

The controls and requirements addressed in the QAPjP are applicable to OU4 Phase I activities, unless specified otherwise in this QAA. Where site-wide actions are applicable to OU4 activities, the applicable section of the QAPjP is referenced in this QAA. This QAA addresses additional and site-specific QA controls and requirements that are applicable to OU4 Phase I activities that may not have been addressed on a site-wide basis in the QAPjP. Many of the QA requirements specific to OU4 are addressed in the OU4 WP and are referenced in this QAA.

**FIGURE 1. PROJECT MANAGEMENT FOR OPERABLE UNIT 10
OTHER OUTSIDE CLOSURES, PHASE I RFI/RI**



10.2.1 Training

Personnel qualification and training requirements for RFP ER Program activities are addressed in Section 2.0 of the QAPjP. Personnel qualifications and training required to perform the EMD Operating Procedures (OPS) that are applicable to OU4 investigations are specified within the respective procedures. The EMD OPS (which are also referred to as SOPs in the QAPjP and the OU4 WP) are identified in Table 10.1.

10.2.2 Quality Assurance Reports to Management

A QA summary report will be prepared annually or at the conclusion of these activities (whichever is more frequent) by the EMD Quality Assurance Project Manager (QAPM) or designee. This report will include a summary of field operation and laboratory inspections, surveillance, and audits and a report on data verification/validation results.

10.3 DESIGN CONTROL AND CONTROL OF SCIENTIFIC INVESTIGATIONS

10.3.1 Design Control

Section 7 describes the Phase I investigation activities that will be implemented to characterize the physical features of the site and define the contaminant sources at OU4. Section 9 describes the Environmental Evaluation (EE) activities to be conducted to characterize the biotic environment and address and quantify the ecological effects from exposure to contaminants within OU4. The OU4 WP identifies the objectives of the investigations; specifies the sampling, analysis, and data generation requirements; and identifies applicable operating procedures that will provide controls for the investigations. As such, the OU4 WP is considered the investigation control plan for OU4 Phase I RFI/RI activities.

10.3.2 Data Quality Objectives

Data needs and data quality objectives (DQOs) for OU4 Phase 1 investigations are addressed in Section 4, and Section 9.2.1 for the Environmental Evaluation (EE) data. The DQOs for the OU4

TABLE 10.1
EMD Operating Procedures and Field Activities
for Which They are Applicable

Former SOP Reference Number			EMD OPS Reference Number	Operating Procedures	Geological Field Surveys	Well Drilling, Completion, Development	Groundwater Sampling	Vadose Zone Monitoring	Soil Sampling	Surface Soil Sampling	Uncontaminated Materials Sampling	Surface Geophysical Surveys	State Sampling
1.1	F0.01	Wind Blown Contaminant Dispersion Control											
1.2	F0.02	Field Document Control											
1.3	F0.03	General Equipment Decontamination											
1.4	F0.04	Heavy Equipment Decontamination											
1.5	F0.05	Handling of Purge and Development Water											
1.6	F0.06	Handling of Personal Protective Equipment											
1.7	F0.07	Handling of Decontamination Water & Wash Water											
1.8	F0.08	Handling of Drilling Fluids & Cuttings											
1.9	F0.09	Handling of Residual Samples											
1.10	F0.10	Receiving, Labeling, and Handling Waste Containers											
1.11	F0.11	Field Communications											
1.12	F0.12	Decontamination Facility Operations											
1.13	F0.13	Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples											
1.14	F0.14	Field Data Management											
1.15	F0.15	Use of PIDs and FIDs											
1.16	F0.16	Field Radiological Measurements											
New	F0.18	Environmental Sample Radioactivity Content Screening											
2.1	GW.01	Water Level Measurements in Wells and Piezometers											
2.2	GW.02	Well Development											
2.5	GW.05	Measurements for Groundwater Field Parameters											
2.6	GW.06	Groundwater Sampling											

X - As required by H&S plan

X - As required by H&S plan.

88600045

TABLE 10.1 (Continued)
EMD Operating Procedures and Field Activities
for Which They are Applicable

TABLE 10.1 (Continued)											
EMD Operating Procedures and Field Activities for Which They are Applicable											
Former SOP Reference Number	EMD OPS Reference Number	Operating Procedures	Geological Field Surveys	Well Drilling, Completion, Development	Surface Zone Monitoring	Surface Water Sampling	Sediment Sampling	Surface Soil Sampling	Unconsolidated Materials Sampling	Surface Geophysical Surveys	Boat Sampling
3.1	GT.01	Logging Alluvial and Bedrock Material	•						•		
3.2	GT.02	Drilling and Sampling Using Hollow-Stem Auger Techniques	•						•		
3.3	GT.03	Isolating Bedrock from the Alluvium with Surface Casing	•						•		
3.4	GT.04	Rotary Drilling and Rock Coring	•						•		
3.5	GT.05	Plugging and Abandonment of Boreholes	•						•		
3.6	GT.06	Monitoring Well and Piezometer Installation	•						•		
3.8	GT.08	Surface Soil Sampling						•			
3.9	GT.09	Soil Gas Sampling and Field Analysis							•		
3.10	GT.10	Borehole Clearing						•			
3.11	GT.11	Plugging and Abandonment of Wells	•						•		
New	GT.15	Geophysical Borehole Logging	•					•			
New	GT.17	Land Surveying	•					•	•		
New	GT.18	Surface Geophysical Surveys							•		
New	GT.22	BAT In-situ Sampler		•							
5.1	EE.01	Sampling of Periphyton									•
5.2	EE.02	Sampling of Benthic Macroinvertebrates									•
5.3	EE.03	Sampling of Plankton									•
5.4	EE.04	Sampling of Fishes									•
5.5	EE.05	Sampling of Large Mammals									•
5.6	EE.06	Sampling of Small Mammals									•
5.7	EE.07	Sampling of Birds									•
5.8	EE.08	Sampling of Reptiles and Amphibians									•
5.9	EE.09	Sampling of Terrestrial Arthropods									•
5.10	EE.10	Sampling of Terrestrial Vegetation									•
5.11	EE.11	Identification of Habitat Types									•
5.12	EE.12	Sampling of Soil for Soil Description									•
5.13	EE.13	Development of Field Sampling Plans									•

Phase I investigations were established in accordance U.S. Environmental Protection Agency (EPA) guidance for developing DQOs, which is summarized in Appendix A of the QAPjP.

The specific objectives, or data needs, of the OU4 Phase I RFI/RI are based on existing site information regarding the nature of contamination present and a site-specific conceptual model for OU4. These specific objectives determine the type of data to be collected. The quality of the data is dependent on the analytical level of the data, which dictates the type of sampling and analytical or measurement quality controls that should be adhered to in generating the data. The EPA has defined five levels of analytical data (Levels I - V). These analytical levels are defined in Section 4 of the WP and Appendix A of the QAPjP. Level I or II analytical or measurement data requires less quality control (QC) than does Level III quantitative data of a known quality.

The intended use of the data determines which analytical level is required for the RFI/RI data to be generated. The type of data that needs to be generated and the analytical level of the data together determine the sampling and analytical or measurement options to be employed to generate measurement data appropriate for its intended use. The data needs, data types, sampling and analysis activities, analytical levels, and data use for the OU4 Phase I RFI/RI are identified in Table 4.1 in Section 4.0 of this Work Plan.

Data quality can be measured in terms of precision, accuracy, representativeness, comparability, and completeness (also referred to as PARCC parameters). These parameters are defined in Appendix A of the QAPjP. PARCC parameter goals are established prior to initiating investigations in order to assist decision makers in determining if DQOs for measurement data have been met.

PARCC parameter goals for measurement data are established so that they are appropriate to the analytical level of the data. Analytical level IV and V data require analysis of environmental samples by EPA approved methods and adherence to QC requirements that are specified by the EPA Contract Laboratory Program (CLP). Historical precision and accuracy measures for EPA Contract Laboratory Program (CLP) analytical and equivalent methods have been determined. These historical measures have been selected as the precision and accuracy goals for all OU4 analytical IV and V data. These historical precision and accuracy measures are listed in Appendix B of the QAPjP.

Accuracy goals for field parameters to be measured during Phase I investigations (analytical level II data, which consists of field analysis or measurements using portable equipment) have been established and are also presented in Appendix B of the QAPjP. DQOs for analytical level I data, which are considered field screening data generated using portable instruments, consist of adhering to approved operating procedures for sampling and analysis, including following applicable instrument calibration requirements.

Goals for representativeness, comparability, and completeness for the OU4 Phase I RFI/RI are specified in Section 4.2.6.

The ecological characterization activities described in Section 9 are considered screening activities that, typically, require Analytical Level I and II data. These characterization data will then be used, along with the OU4 RFI/RI characterization and source contamination data, to develop the conceptual model for the EE study. Data quality for these characterization activities will be controlled by adhering to the field sampling operating procedures in implementing the EE Field Sampling Plan (Section 9.3).

The conceptual model developed for the OU4 ecosystem will assist investigators in identifying site-specific target species, contaminants of concern, and potential exposure pathways. Additional DQOs for the contamination assessment tasks (Tasks 4 through 7 of Section 9) and the ecotoxicological studies (Task 8) will then be developed following steps recommended by the EPA in EPA/600/3-89/013, Ecological Assessments of Hazardous Waste Sites: A Field Guide and Laboratory Reference Document, and EPA/540/G-90/008, Guidance for Data Usability in Risk Assessment. The ecosystem characterization data and preliminary aquatic toxicity investigation data that will be obtained by implementing the EE Field Sampling Plan are needed to develop these additional DQOs.

10.3.3 Sampling Locations and Sampling Procedures

The sampling activities to be conducted to generate the data needed to meet the Phase I RFI/RI objectives include:

- Installation of upgradient groundwater monitoring wells
- Site-wide radiological survey and surficial soil sampling
- Site-wide vadose zone monitoring
- Field sampling and geophysical investigation in the vicinity of the Original Pond
- Field sampling and geophysical investigation of the existing Solar Ponds area
- Field sampling and geophysical investigation of the Interceptor Trench System.

The field sampling design, including sampling locations, frequencies, methods, and procedures are described in Section 7.3. Sampling locations, frequencies, and procedures for the EE program, consisting of vegetation, periphyton, benthic macroinvertebrate, fish, and small mammals sampling, are addressed in Section 9.3.

The operating procedures that are applicable to OU4 Phase I field activities and the particular activities to which they are applicable are summarized in Table 10.1.

10.3.4 Analytical Procedures

The analytical program for the OU4 Phase I RFI/RI is discussed in Section 7.4. The analytes of interest and the specified detection limits are identified in Table 7.1. The analytical methods that shall be adhered to are those that are specified in the EG&G Rocky Flats General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Parts A and B. These methods are referenced in Section 3.0 of the QAPjP. Specific analytical methods for each analyte identified in Section 7.4 are referenced in Appendix B of the QAPjP.

10.3.5 Equipment Decontamination

Non-dedicated sampling equipment (i.e., sampling equipment that is used at more than one location) shall be decontaminated between sampling locations in accordance with OPS-FO.03, General Equipment Decontamination. Other equipment (e.g., heavy equipment) potentially contaminated during drilling, hydrogeologic/geologic testing, boring, sample collection, etc. shall also be decontaminated as specified in OPS-FO.04, Heavy Equipment Decontamination.

10.3.6 Air Quality

Air monitoring will be conducted during implementation of field activities that have the potential to create windblown dispersion of contaminants, including drilling, coring, and installation of monitoring wells. Air monitoring will ensure that OU4 RFI/RI activities comply with the RFP Interim Plan for Prevention of Contaminant Dispersion. Air monitoring will be conducted according to OPS-FO.01, Wind Blown Contaminant Dispersion Control.

10.3.7 Quality Control

To ensure the quality of the field sampling techniques, collection and/or preparation of field quality control (QC) samples are incorporated into the sampling scheme. Field QC samples and collection frequencies for OU4 are addressed in Section 7.6 and identified in Table 7.4. A specific sampling schedule will be prepared by the sampling subcontractor for approval by the EG&G Laboratory Analysis Task Leader (Figure 10-1) prior to sampling.

10.3.7.1 Objectives for Field QC Samples:

Equipment rinsate blanks are considered acceptable (with no need for data qualification) if the concentration of analytes of interest is less than three times the required detection limit for each analyte as specified in Table 7.1. Field duplicate samples shall agree within 30 percent relative percent difference for aqueous samples and 40 percent for homogenous, non-aqueous samples.

Trip blanks and field preservation blanks (for organics and inorganics, respectively) indicate possible field contamination when analytes are detected above the minimum detection limits presented in Table 7.1. The Laboratory Analysis Task Leader (Figure 10-1) is responsible for verifying these criteria and shall be responsible for checking to see if they are met and for qualifying data.

10.3.7.2 Laboratory QC

Laboratory QC procedures are used to provide measures of internal consistency of analytical and storage procedures. The laboratory contractor will submit written SOPs to the Laboratory Analysis Task Leader for approval. The interlaboratory SOPs shall be consistent with or equivalent to EPA-CLP QC procedures. The laboratory SOPs must cover the following areas in sufficient detail and reflect actual operating conditions in effect during analysis of EG&G RFP samples:

- Sample receipt and log-in
- Sample storage and security
- Facility security
- Sample tracking (from receipt to sample disposition)
- Sample analysis method references
- Data reduction, verification, and reporting
- Document control (including submitting documents to EG&G)
- Data package assembly (see Section III.A of the GRRASP)
- Qualifications of personnel
- Preparation of standards
- Equipment maintenance and calibration
- List of instrumentation and equipment (including date purchased, date installed, model number, manufacturer, and service contracts, if any)
- Instrument detection limits
- Acceptance criteria for non-CLP analyses
- Laboratory QC checks applicable to each analytical method

Laboratory QC techniques to ensure consistency and validity of analytical results (including detecting potential laboratory contamination of samples) include using reagent blanks, field blanks,

internal standard reference materials, laboratory replicate analysis, and field duplicates. The laboratory contractor will follow the standard evaluation guidelines and QC procedures, including frequency of QC checks, that are applicable to the particular type of analytical method being used as specified in Parts A and B of the GRRASP and Section 3.0 of the QAPjP. All data packages will be forwarded to the Laboratory Analysis Task Leader or validation contractor (Figure 10-1) for review and verification.

10.3.8 Quality Assurance Monitoring

To assure the overall quality of the RFI/RI activities discussed in the OU4 WP, field inspections will be conducted daily and audits and surveillance will be conducted at various intervals. The intervals will be determined by the importance and complexity of each activity. Intervals will also be based on the schedule contained in Section 6.0. At a minimum, each of the field sampling activities described in Sections 7.3 and 9.3 will be monitored by an independent surveillance team at least once during the sampling process. EG&G will conduct audits of the laboratory contractor(s) as specified in the GRRASP, Parts A and B. The audits and surveillance, and activity Readiness Reviews are discussed further in Section 10.18.

10.3.9 Data Reduction, Validation, and Reporting

10.3.9.1 Analytical Reporting Turnaround Times

Analytical reporting turnaround times are as specified in Table 3-1 of Section 3.0 of the QAPjP.

10.3.9.2 Data Reduction

Reduction of laboratory measurements shall be in accordance with the methods specified for each analytical method. Laboratory data will be compiled into sample data packages by the laboratory contractor. A sample data package shall be developed for each sample delivery group or sample batch, with separate data packages for each type of analysis (e.g., a data package for organics, one for inorganics, one for water quality parameters, and one for radionuclides). The sample data package shall consist of a cover sheet/transmittal letter, a case narrative, data summary forms, and

copies of the data checklists found in Attachments I in Parts A and B of the GRRASP. The reduced data will be used in the data validation process to verify that the laboratory control and the overall system DQOs have been met.

10.3.9.3 Data Validation

Validation activities consist of reviewing and verifying field and laboratory data and evaluating these verified data for data quality (i.e., comparison of reduced data to DQOs, where appropriate). The field and laboratory data validation activities and guidelines are described and referenced in Section 3.0 of the QAPjP. The process for validating the quality of the data is illustrated graphically in Figure 3-1 of Section 3.0 of the QAPjP, and is also included as part of the sample collection, chain-of-custody, and analysis process illustrated in Figure 8-1 of Section 8.0 of the QAPjP. The criteria for determining the validity of ER Program data at Rocky Flats are described in subsection 3.3.7 of Section 3.0 of the QAPjP.

10.3.9.4 Data Management and Reporting

Data management and reporting requirements are specified in Section 7.5.

10.4 PROCUREMENT DOCUMENT CONTROL

Procurement documents for items and services, including services for conducting field investigations and analytical laboratories, shall be prepared, handled, and controlled in accordance with the requirements and methods specified in Section 4.0 of the QAPjP.

10.5 INSTRUCTIONS, PROCEDURES, AND DRAWINGS

The OU4 WP describes the activities to be performed. The OU4 WP will be reviewed and approved in accordance with the requirements for instructions, procedures, and drawings outlined in Section 5.0 of the QAPjP.

EMD OPS approved for use are identified in Table 10.1, which also indicates their applicability. Any additional quality-affecting procedures proposed for use but not identified in Table 10.1 will be developed and approved as required by Section 5.0 of the QAPjP prior to performing the affected activity.

Changes and variances to approved operating procedures and the OU4 WP shall be documented through preparation of Document Change Notices (DCNs), which will be prepared, reviewed, and approved in accordance with requirements specified in Section 5.0 of the QAPjP. (Note: DCNs were referred to as Procedure Change Notices in Revision 0 of the QAPjP).

10.6 DOCUMENT CONTROL

The following documents will be controlled in accordance with Section 6.0 of the QAPjP:

- "Phase I RFI/RI Work Plan for Rocky Flats Plant Solar Evaporation Ponds (Operable Unit No. 4)"
- "Rocky Flats Plant Site-Wide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities" (QAPjP)
- EMD Operating Procedures (all operating procedures specified in the QAPjP, this QAA, and to-be-developed laboratory SOPs).

10.7 CONTROL OF PURCHASED ITEMS AND SERVICES

Contractors that provide services to support the OU4 WP activities will be selected and evaluated as outlined in Section 7.0 of the QAPjP. This includes preaward evaluation/audit of proposed contractors as well as periodic audit of the acceptability of contractor performance during the life of the contract. Any items or materials that are purchased for use during the OU4 investigations that have the ability to affect the quality of the data shall be inspected upon receipt.

10.8 IDENTIFICATION AND CONTROL OF ITEMS, SAMPLES, AND DATA

10.8.1 Sample Containers/Preservation

Appropriate volumes, containers, preservation requirements, and holding times for water and soil samples are presented in Tables 7.2 and 7.3. Requirements for EE samples are included here in Table 10.2.

10.8.2 Sample Identification

RFI/RI samples shall be labeled and identified in accordance with Section 8.0 of the QAPjP and OPS-FO.13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples. Samples shall have unique identification that traces the sample to the source(s) and indicates the method(s), date, the sampler(s), and conditions prevailing at the time of sampling.

10.8.3 Chain-of-Custody

Sample chain-of-custody will be maintained through the application of OPS-FO.13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples, and as illustrated in Figure 8-1 of the QAPjP for all environmental samples collected during field investigations.

10.9 CONTROL OF PROCESSES

The overall process of collecting samples, performing analysis, and inputting the data into a database is considered a process that requires control. The process is controlled through a series of written procedures that govern and document the work activities. A process diagram is shown in Section 8.0 of the QAPjP.

TABLE 10.2
HOLDING TIMES, PRESERVATION METHODS, AND SAMPLE CONTAINERS FOR BIOTA SAMPLES

	Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size*
SAMPLES FOR METALS ANALYSES				
<u>TERRESTRIAL VEGETATION</u>				
- Metals Determined by ICP**	6 mos.	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Metals Determined by GFAA***	6 mos.	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Hexavalent Chromium	24 hours	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Mercury	28 days	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	5 g
<u>Periphyton and Benthic Macroinvertebrates</u>				
- Metals Determined by ICP	6 mos.	Freeze & ship w/dry ice	Plastic	25 g
- Metals Determined by GFAA	6 mos.	Freeze & ship w/dry ice	Plastic	25 g
- Hexavalent Chromium	24 hours	Freeze & ship w/dry ice	Plastic	25 g
- Mercury	28 days	Freeze & ship w/dry ice	Plastic	5 g

TABLE 10.2
HOLDING TIMES, PRESERVATION METHODS, AND SAMPLE CONTAINERS FOR BIOTA SAMPLES

SAMPLES FOR RADIONUCLIDE ANALYSES				
	Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size *
<u>Terrestrial Vegetation</u>				
- Uranium 223, 234, 235, 238 Americium 241 Plutonium 239, 240	6 mos.	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	1 kg
<u>Periphyton and Benthic Macroinvertebrates</u>				
- Uranium 233, 234, 235, 238 Americium 241 Plutonium 239, 240	6 mos.	Freeze & ship w/dry ice	Plastic	1 kg

* Sample size may vary with specific laboratory requirements.

**ICP = Inductively Coupled Argon Plasma Emission Spectroscopy. Metals to be determined include Ba, Cr, Cu, and Fe.

***GFAA = Graphite Furnace Atomic Absorption Spectroscopy. Metals to be determined include As, Cd, Li, Pb, Se, and Sr.

10.10 INSPECTION

Procured materials and construction activities (e.g., groundwater monitoring well installation) shall be inspected (as applicable) in accordance with the requirements specified in Section 10.0 of the QAPjP.

10.11 TEST CONTROL

Test control requirements specified in Section 11.0 of the QAPjP are not applicable to any of the RFI/RI investigations described in the OU4 WP.

10.12 CONTROL OF MEASURING AND TEST EQUIPMENT (M&TE)

10.12.1 Field Equipment

Specific conductivity, temperature, pH, and dissolved oxygen content, chlorine, turbidity, and alkalinity of water samples shall be measured in the field. Field measurements will be taken and the instruments calibrated as specified in OPS-SW.02, Field Measurements of Surface Water Parameters. Measurements shall be made using the following equipment (or EG&G-approved alternates):

- Temperature: mercury-filled, teflon-coated, safety-type thermometer (VWR catalogue No. 6107-832 or equivalent), or digital readout thermistor (VWR Catalogue No. 61017-562 or equivalent)
- Specific Conductivity: HACH 44600 Conductivity/TDS Meter
- Dissolved Oxygen: HACH or YSI Model 57 Dissolved Oxygen Meter
- pH: HACH One pH Meter (this meter may also be used for temperature measurements)
- Chlorine and Turbidity: HACH DR2000 spectrophotometer
- Alkalinity: HACH digital titrator

In addition to the field measurements for water quality, field measurements for radiation, soil gas, and VOCs in groundwater will also be made. The following instruments will be used for these measurements.

- Radiological field readings for field survey grid locations and drill cuttings, core, and samples: A side-shielded field instrument for detection of low energy radiation (FIDLER), Ludlum Model 12-1A or equivalent. Use, calibration, and maintenance will be according to OPS-FO-16, Field Radiological Measurements.
- Field readings for soil gas and VOCs in groundwater: A portable photoionization detector (PID), HNU Systems P1-101 or equivalent. Use, calibration, and maintenance will be according to OPS-FO.15, Photoionization Detectors (PIDs) and Flame Ionization Detectors (FIDs).

Each piece of field equipment shall have a file that contains:

- Specific model and instrument serial number
- Operating instructions
- Routine preventative maintenance procedures, including a list of critical spare parts to be provided or available in the field
- Calibration methods, frequency, and description of the calibration solutions
- Standardization procedures (traceability to nationally recognized standards).

The above information shall, in general, conform to the manufacturer's recommended operating instructions or shall explain the deviation from said instructions.

10.12.2 Laboratory Equipment

Laboratory analyses will be performed by contracted laboratories. The equipment used to analyze environmental samples shall be calibrated, maintained, and controlled in accordance with the requirements contained in the specific analytical protocols used as specified in Parts A and B of the GRRASP. This information will be supplied to EG&G as a laboratory SOP.

10.13 HANDLING, STORAGE, AND SHIPPING

Samples shall be packaged, transported, and stored in accordance with OPS-FO.13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples. Maximum sample holding times, sample preservative, sample volumes, and sample containers are specified in Table 8-1 of Section 8.0 of the QAPjP. Sample handling and storage controls at the laboratory shall be provided as a laboratory SOP.

10.14 STATUS OF INSPECTION, TEST, AND OPERATIONS

The requirements for the identification of inspection, test, and operating status shall be implemented as specified in Section 14.0 of the QAPjP. A log specifying the status of all boreholes and groundwater monitoring wells shall be maintained by the Field Activities Task Leader, which will include well/borehole identification number, ground elevation, casing depth of hole, depth to bedrock, static water level (as applicable), depth to top and bottom of screen (as applicable), diameter of hole, diameter of casing, and top/bottom of casing.

10.15 CONTROL OF NONCONFORMANCES

The requirements for the identification, control, evaluation, and disposition of nonconforming items, samples, and data will be implemented as specified in Section 15.0 of the QAPjP. Nonconformances identified by the implementing contractor shall be submitted to EG&G for processing as outlined in the QAPjP.

10.16 CORRECTIVE ACTION

The requirements for the identification, documentation, and verification of corrective actions for conditions adverse to quality will be implemented as outlined in Section 16.0 of the QAPjP. Conditions adverse to quality identified by the implementing contractor shall be documented and submitted to EG&G for processing as outlined in the QAPjP.

10.17 QUALITY ASSURANCE RECORDS

QA records will be controlled in accordance with OPS-FO.02, Field Document Control. QA records to be generated during OU4 RFI/RI Phase I activities include, but are not limited to:

- Field Logs and Data Record Forms (e.g., sample collection notebooks/logs for water, sediment, and air)
- Calibration Records
- Sample Collection and Chain-of-Custody Records
- Laboratory Sample Data Packages
- Drilling Logs
- Work Plan/Field Sampling Plan/QAA
- QAPjP
- Audit/Surveillance/Inspection Reports
- Nonconformance Reports
- Corrective Action Documentation
- Data Validation Results
- Data Reports
- Procurement/Contracting Documentation
- Training/Qualification Records
- Inspection Records

10.18 QUALITY VERIFICATION

The requirements for the verification of quality shall be implemented as specified in Section No. 18 of the QAPjP. EG&G will conduct audits of the laboratory contractor as specified in the GRRASP, Parts A and B. The EMD QAPM shall develop a surveillance schedule with the surveillance intervals based on the importance and complexity of each sampling/analytical activity. Intervals will also be based on the schedule contained in Section 6.0.

Examples of some specific tasks that will be monitored by the surveillance program are as follows:

- Borings and well installations (approximately 10 percent of the holes)
- Field sampling (approximately 5 percent of each type of sample collected)
- Records management (a surveillance will be conducted once at the initiation of OU4 activities, and monthly thereafter)
- Data verification, validation, and reporting

Audits of contractors providing field investigation, construction, and analytical support services shall be performed at least annually or once during the life of the project, whichever is more frequent.

A Readiness Review shall be conducted by the EMD QAPM prior to the implementation of OU4 field investigation activities. The readiness review will determine if all activity prerequisites have been met that are required to begin work. The applicable requirements of the QAPjP and this QAA will be addressed.

10.19 SOFTWARE CONTROL

The requirements for the control of software shall be implemented as specified in Section 19.0 of the QAPjP. Only database software is anticipated to be used for the OU4 WP activities. Operating procedures applicable to the use of the database storing environmental data can be found in OPS-FO.14, Field Data Management.

11.0 STANDARD OPERATING PROCEDURES AND ADDENDA

The following RFP program-wide SOPs will be utilized during the specific field investigations for OU4:

- F0.1 Windblown Contaminant Dispersion Control
- F0.2 Field Document Control
- F0.3 General Equipment Decontamination
- F0.4 Heavy Equipment Decontamination
- F0.5 Handling Purge and Development Water
- F0.6 Handling of Personal Protective Equipment
- F0.7 Handling of Decontamination Water and Wash Water
- F0.8 Handling of Drilling Fluids and Cuttings
- F0.9 Handling of Residual Samples
- F0.10 Receiving, Labeling, and Handling of Waste Containers
- F0.11 Field Communications
- F0.12 Decontamination Facility Operations
- F0.13 Containerizing, Preserving, Handling, and Shipping Soil and Water Samples
- F0.14 Field Data Management
- F0.15 Use of Photoionizing and Flame Ionizing Detectors
- F0.16 Field Radiological Measurements
- F0.18 Environmental Sample Radioactivity Content Screening
- GW.1 Water Level Measurements in Wells and Piezometers
- GW.2 Well Development
- GW.5 Measurement of Ground water Field Parameters
- GW.6 Ground water Sampling
- GT.1 Logging Alluvial and Bedrock Material
- GT.2 Drilling and Sampling Using Hollow-Stem Auger Techniques
- GT.3 Isolating Bedrock from Alluvium Using Grouted Surface Casing
- GT.4 Rotary Drilling and Rock Coring
- GT.5 Plugging and Abandonment of Wells
- GT.6 Monitoring Well and Piezometer Installation
- GT.8 Surface Soil Sampling
- GT.10 Borehole Clearing
- GT.15 Geophysical Borehole Logging
- GT.18 Surface Geophysical Surveys

All Volume V Ecology (EE) SOPs.

Specific information regarding most sampling activities is provided in the FSP (Section 7.0). Project-specific details for this Work Plan will be included in the Document Change Notices (DCNs). These DCNs will be attached to the SOP for use during field activities.

These documents will be available for review prior to issuing the Final Phase I RFI/RI Work Plan for OU4.

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**APPENDICES A THROUGH G
ARE CONTAINED IN A SEPARATE VOLUME (VOLUME II)**

APPENDIX A

ENGINEERING AND CONSTRUCTION DRAWINGS

- Location maps of Original Process Waste Lines and underground utilities
- As built Interceptor Trench System diagrams
- Solar Pond area engineering drawings and as built diagrams
- Site utility plans

APPENDIX B
SUBSURFACE GEOLOGIC DATA
SOLAR PONDS AREA

- Tabulated subsurface borehole data
- Boring logs

APPENDIX C

**GROUND WATER LEVEL DATA
SOLAR PONDS AREA**

- Ground water level data from RFEDS database

APPENDIX D

SOLAR EVAPORATION POND LIQUID AND SLUDGE ANALYTICAL RESULTS

- Summary of analytical results compiled for SEP Closure Plan, July 1988
- Analytical results obtained by Weston, July 1991
- Summary of analytical data compiled by Dames & Moore, September 1991

APPENDIX E

SOIL ANALYTICAL RESULTS SOLAR PONDS AREA

- Analytical results of 1989 soil sampling
- Background geochemical characterization results for alluvial and bedrock samples
- Results of radiological surveys in Pond 207-A area

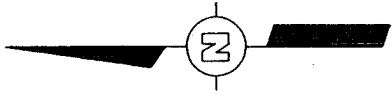
APPENDIX F

GROUND WATER ANALYTICAL RESULTS SOLAR PONDS AREA

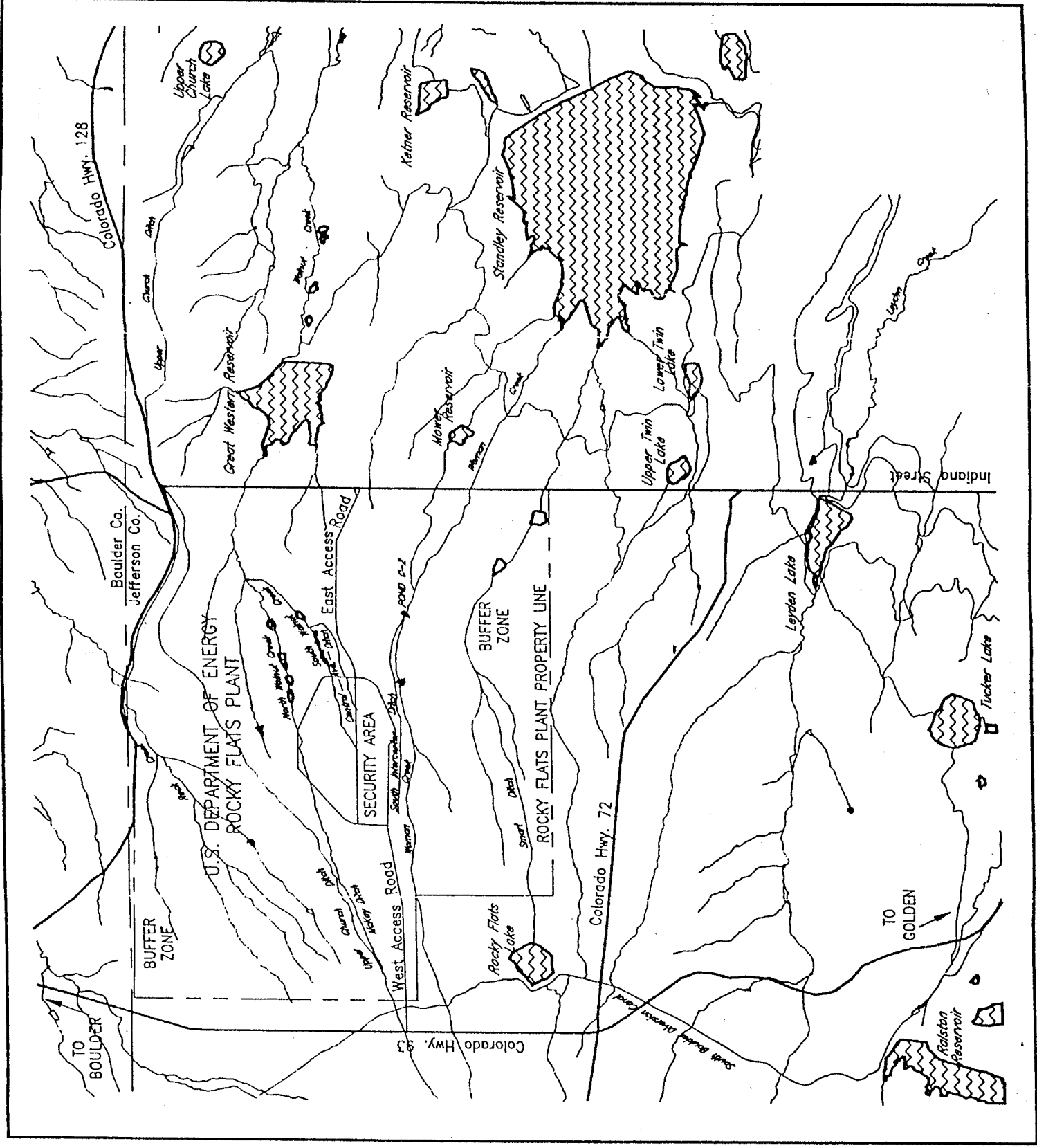
- Ground water analytical data from surficial materials, 1990
- Ground water analytical data from weathered bedrock, 1990
- Ground water analytical data from 1989 borings, VOCs only

APPENDIX G
AIR MONITORING DATA
ROCKY FLATS PLANT

- Monthly results from Radioactive Ambient Air Monitoring Program (RAAMP), 1988-1991



SCALE 1" = 1 MILE
0 1/2 1 MILE



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Golden, Colorado

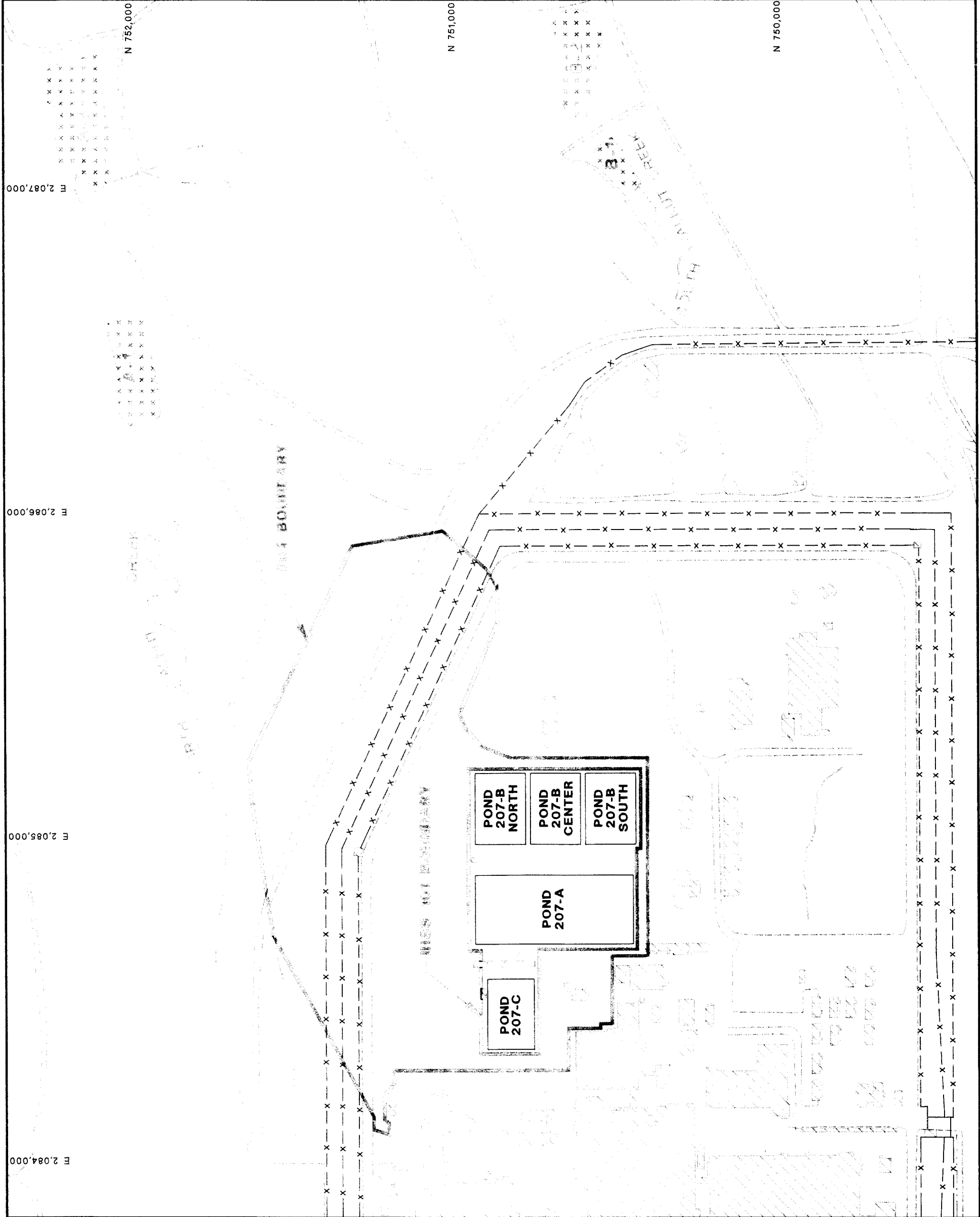
FIGURE 1-2

TITLE:

**ROCKY FLATS PLANT
AND VICINITY SURFACE
WATER DRAINAGES**

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DESIGN BY	G. BRAND	CHECKED	G. BRAND	OF
DRAWN BY	R. HYNA	APPROVED		
DATE	10/10/91	SCALE	AS NOTED	

REFERENCE: EG&G DRAFT PHASE I
RFI/R1 WORK PLAN
FOR OU-7, JULY 1991.



LEGEND

ROADS

DRAINAGE / STREAM

IHSS 101 BOUNDARY

OU4 BOUNDARY

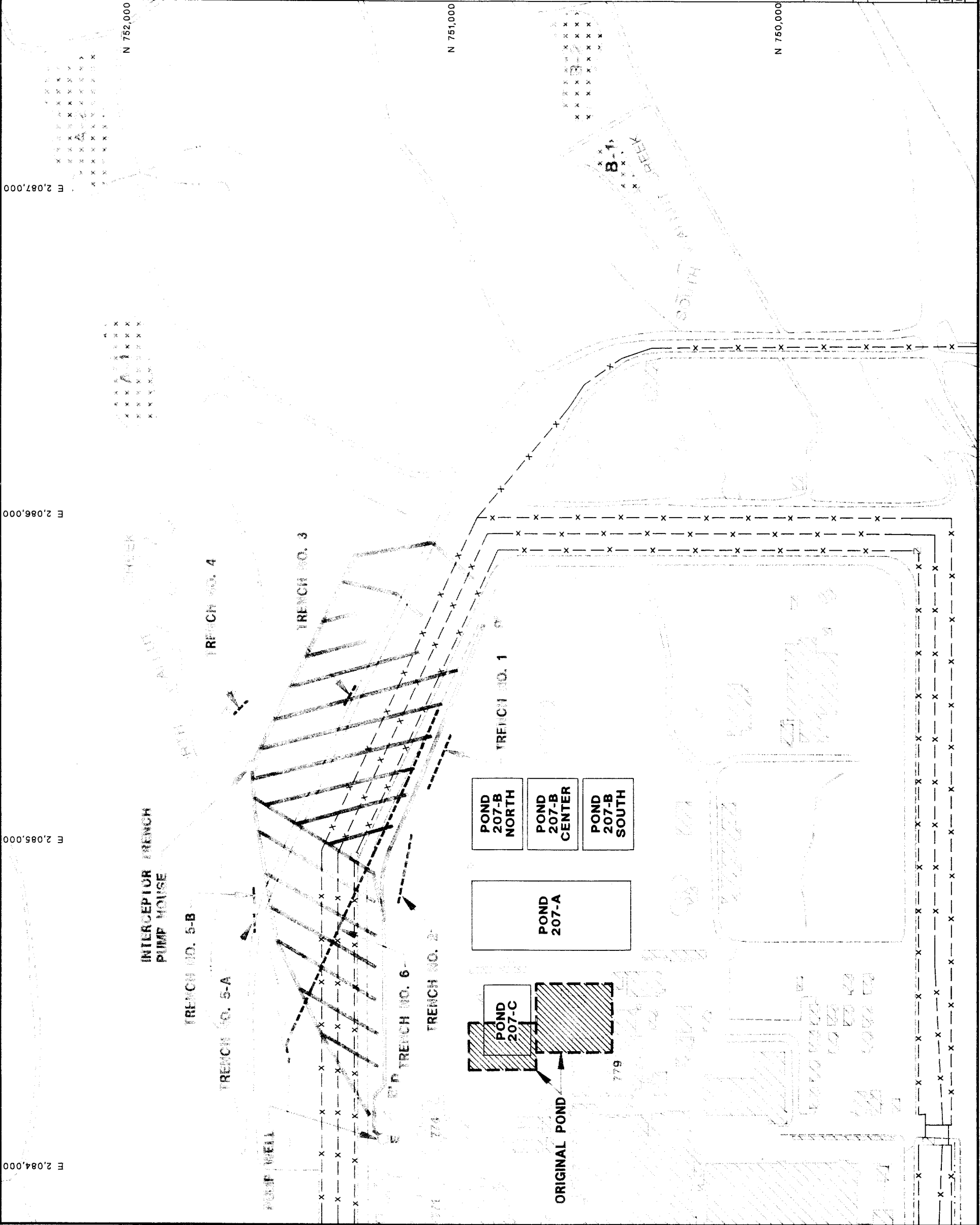


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Golden, Colorado

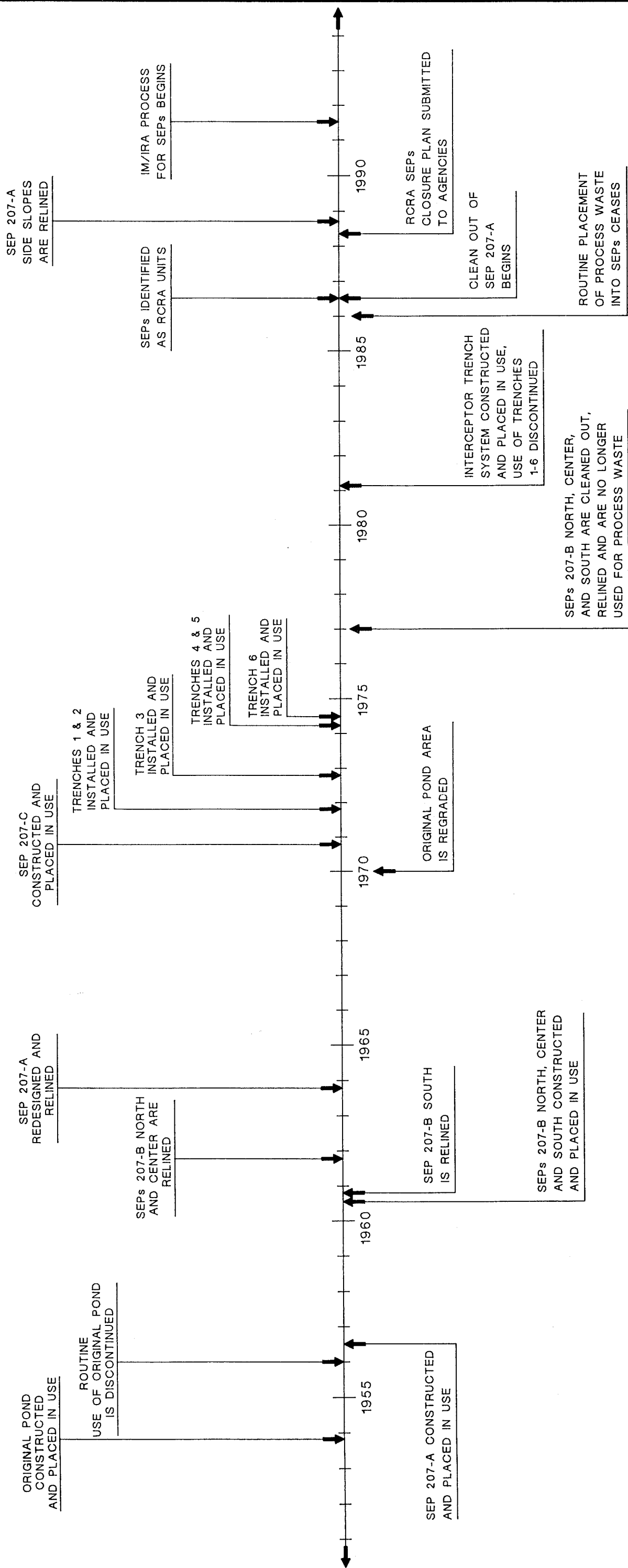
FIGURE 2-1

TITLE:
**OU4 AND IHSS 101
BOUNDARY**

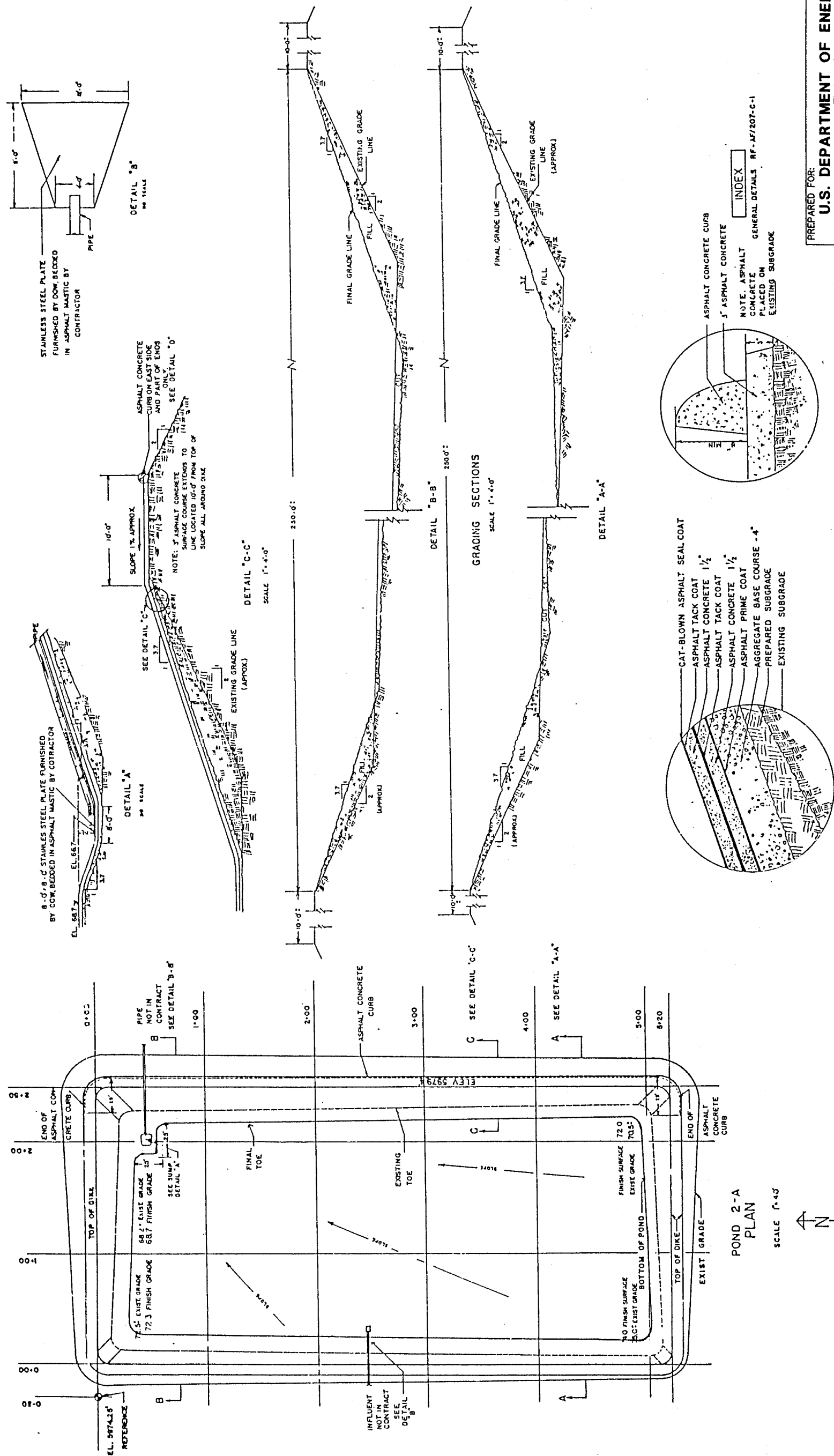
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304900	304909-B46	G. BRAND	BENTZ	10/20/91	1=300	10/25



PREPARED FOR: U.S. DEPARTMENT OF ENERGY Rocky Flats Plant Golden, Colorado			
FIGURE 2-2			
TITLE: MAJOR FEATURES IN THE SOLAR EVAPORATION POND AREA			
PROJ. NO.	304900	DWG. NO.	304909-B31
DESIGN BY	G. BRAND	CHECKED	J. J. J.
DRAWN BY	BENTZ	APPROVED	
DATE	10-10-91	SCALE	1=300
			SHEET OF



PREPARED FOR: U.S. DEPARTMENT OF ENERGY Rocky Flats Plant Golden, Colorado			
FIGURE 2-3			
TITLE: SUMMARY OF MAJOR EVENTS AT THE SOLAR EVAPORATION PONDS			
PROJ. NO.	304909	DWG. NO.	304909-B39
DESIGN BY	G. BRAND	CHECKED	G. BRAND
DRAWN BY	R. HYNÄ	APPROVED	
DATE	10/15/91	SCALE	NTS
			SHEET OF



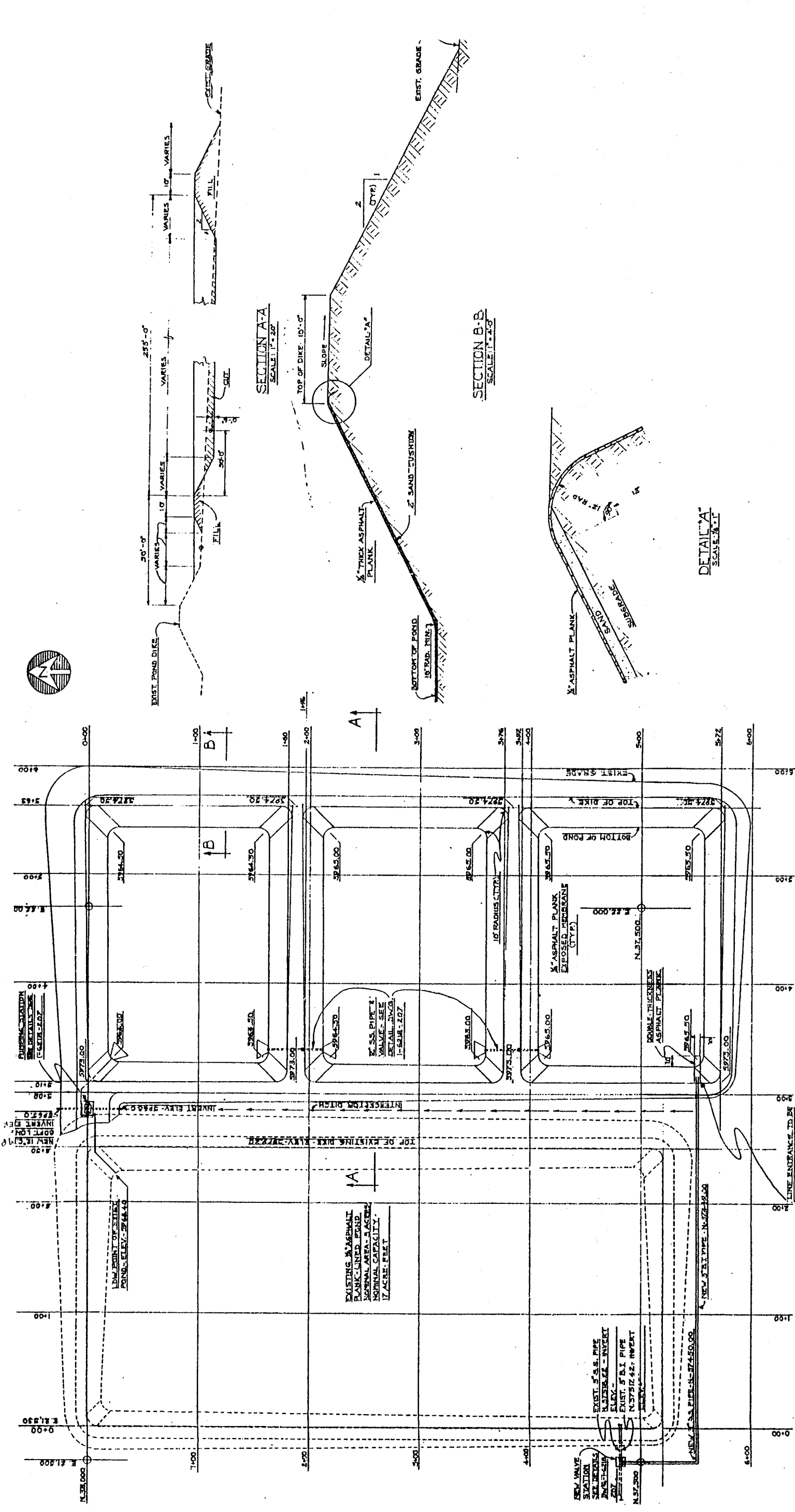
PREPARED FOR: U.S. DEPARTMENT OF ENERGY Rocky Flats Plant Golden, Colorado			
FIGURE 2-5			
TITLE: POND 207-A NOVEMBER 1963 RELINING DETAILS			
PROJ. NO.	DWG. NO.	304909-B52	SHEET
DESIGN BY	C. BRAND	CHECKED	OF
DRAWN BY	KRONER	APPROVED	
DATE	10-21-91	SCALE	NA

DETAIL "C" SCALE 1"=4'-0"

DETAIL "D" NO SCALE

REFERENCE: MODIFIED AFTER U.S. ATOMIC ENERGY COMMISSION, DRAWING RF-AF/207-C-1 (1963).

REFERENCE: MODIFIED AFTER DOW CHEMICAL COMPANY, DRAWING NUMBER 1-6217-207 (1959).



PLAN
SCALE 1"=40'

NOTES:
1. EMBANKMENT AND EXCAVATION ARE APPROXIMATELY BALANCED. IF ADDITIONAL EMBANKMENT IS REQUIRED, A BORROW AREA WILL BE DESIGNATED IN THE ADJACENT AREA AND IF EXCAVATION IS GREATER THAN NEEDED, THE SURPLUS SHALL BE DEPOSITED ON THE EXTERIOR SIDE OF THE NORTH AND EAST DIKES.
2. ALL PIPING FOR PUMPING STATION SHALL BE STAINLESS STEEL 304-L P.L.C.
3. ALL EXPOSED MILD STEEL SHALL BE GIVEN ONE COAT OF SHOP PRIMER AND 2 COATS OF MACHINERY GREY PAINT.

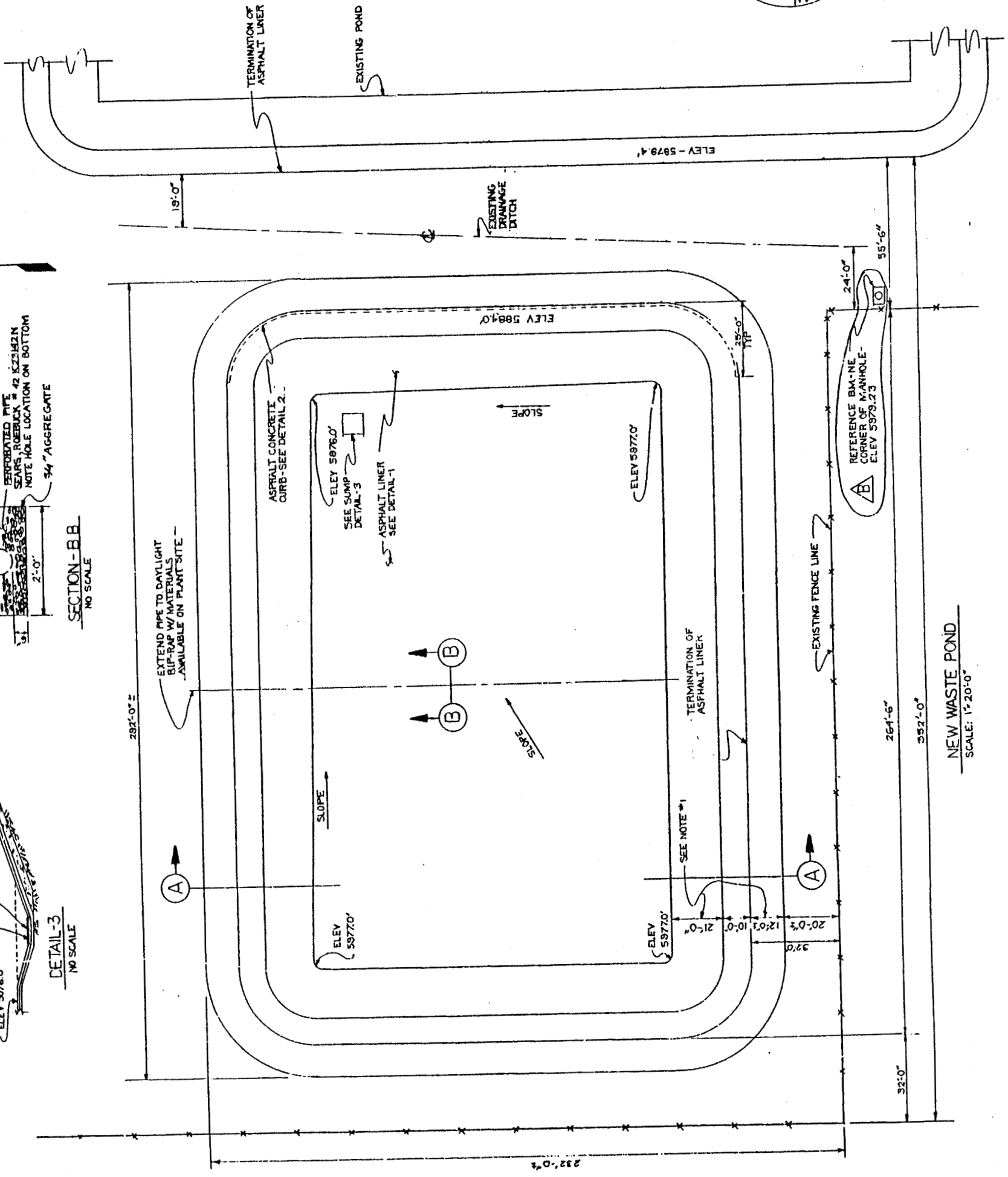
PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado
FIGURE 2-6

TITLE:
**POND 207-B
(NORTH, CENTER & SOUTH)
PLAN AND SECTIONS**

PROJ. NO.	304909	DWG. NO.	304909-B53	SHEET
DESIGN BY	G. BRAND	CHECKED	HUB	OF
DRAWN BY	KRONER	APPROVED		
DATE	10-21-91	SCALE	NA	

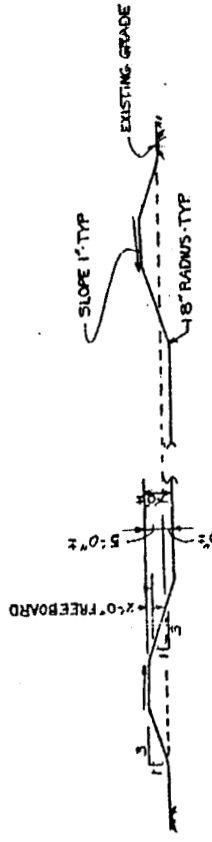
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NEW WASTE POND
SCALE: 1"=20'-0"



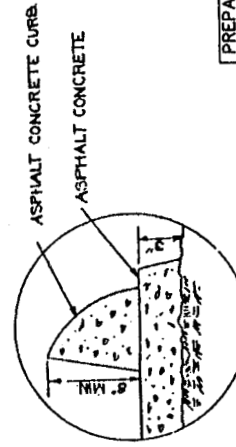
- CAT BLOWN ASPH SEAL COAT
- ASPHALT TACK COAT
- ASPHALT CONCRETE 1 1/2"
- ASPHALT TACK COAT
- ASPHALT CONCRETE 1 1/2"
- ASPHALT PRIME COAT
- AGGREGATE BASE COURSE 4"
- PREPARED SUBGRADE

DETAIL-1 - ASPHALT LINER
NO SCALE



GENERAL NOTES

1. DIMENSIONS VARY BECAUSE OF DIFFERENT FINISHED ELEVATIONS OF BOTTOM OF POND AND DIFFERENT ELEVATIONS OUTSIDE OF TOE OF SLOPE.
2. SEE DWGS 15301-16421 FOR UNDERGROUND UTILITIES

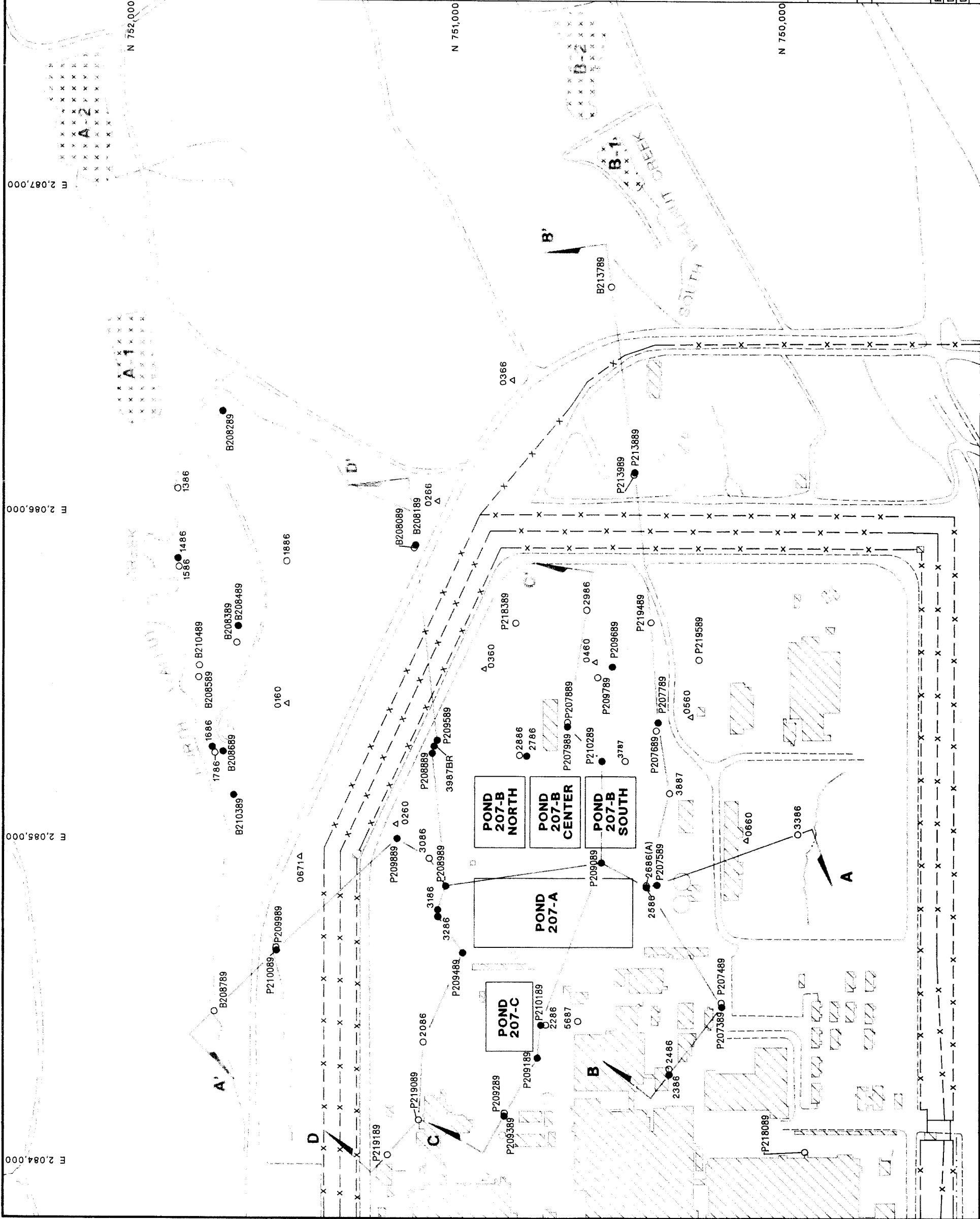


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Rocky Flats Plant
Golden, Colorado

FIGURE 2-7

POND 207-C
PLAN AND DETAILS

PROJ. NO.	304909	DWG. NO.	304909-B54	SHEET
DESIGN BY	G. BRAND	CHECKED	MA/B	OF
DRAWN BY	KRONER	APPROVED		
DATE	10-21-91	SCALE	NA	



LEGEND

- P218389
O ALLUVIAL WELLS
- Δ 0360
PRE-1986 WELLS
- P209489
● BEDROCK WELLS
- ROADS
- DRAINAGE / STREAM
- CROSS SECTION LOCATION

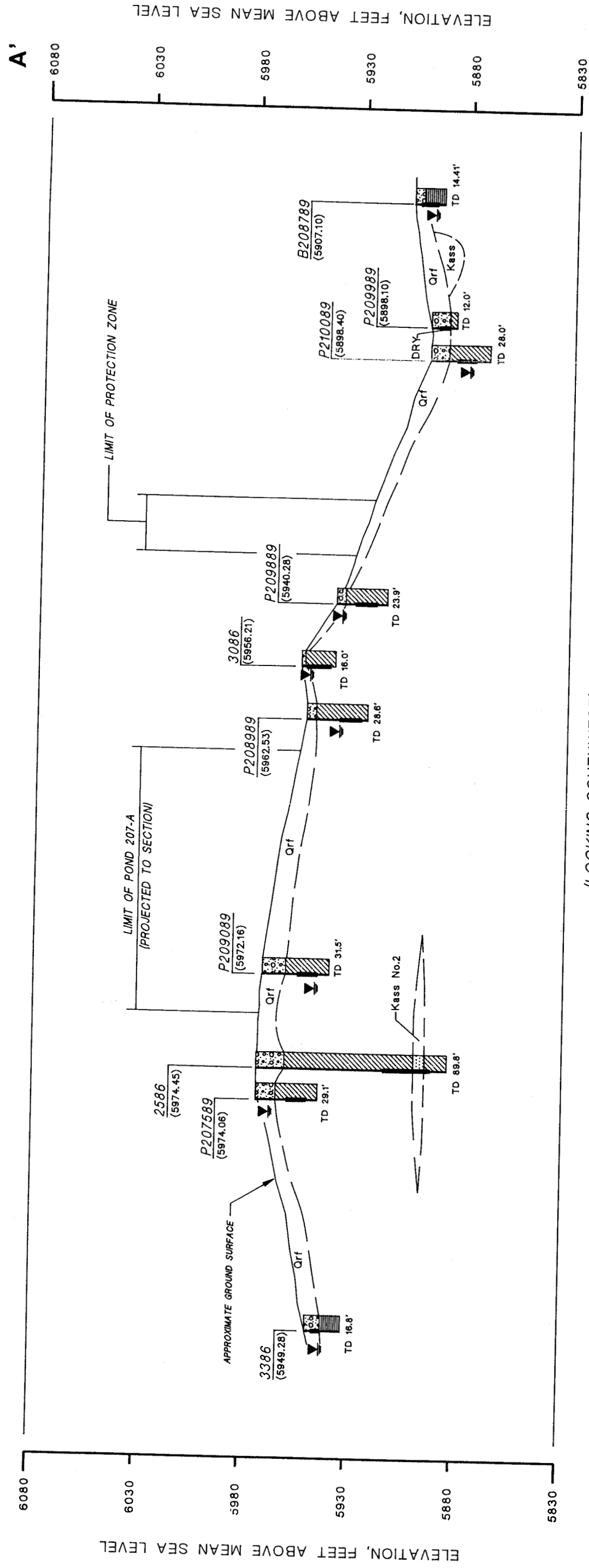
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Rocky Flats Plant
Golden, Colorado

FIGURE 2-9

LOCATION MAP
GEOLOGIC CROSS SECTIONS
A-A', B-B', C-C' AND D-D'

PROJ. NO.	DWG. NO.	304909-B28	SHEET
DESIGN BY	CHECKED	JJZ	OF
DRAWN BY	APPROVED	C. BENTZ	
DATE	10/18/91	SCALE	1=300

A



(LOOKING SOUTHWEST)

LEGEND

QUATERNARY		CRETACEOUS	
GRAVEL	Qrt	SANDSTONE	Kass
		SILTY CLAYSTONE	Kasc
		CLAYSTONE	Kacs
		ARAPAHOE SANDSTONE	
		ARAPAHOE SILTY CLAYSTONE	
		ARAPAHOE CLAYSTONE	

HORIZONTAL SCALE



VERTICAL SCALE



THE BORING LOGS AND RELATED INFORMATION DEPICT SUBSURFACE CONDITIONS ONLY AT THE SPECIFIC LOCATIONS AND DATES INDICATED. SOIL CONDITIONS AND WATER LEVELS AT THESE LOCATIONS MAY DIFFER FROM CONDITIONS OCCURRING AT THESE BORING LOCATIONS. ALSO, THE PASSAGE OF TIME MAY RESULT IN A CHANGE IN THE CONDITIONS AT THESE BORING LOCATIONS.

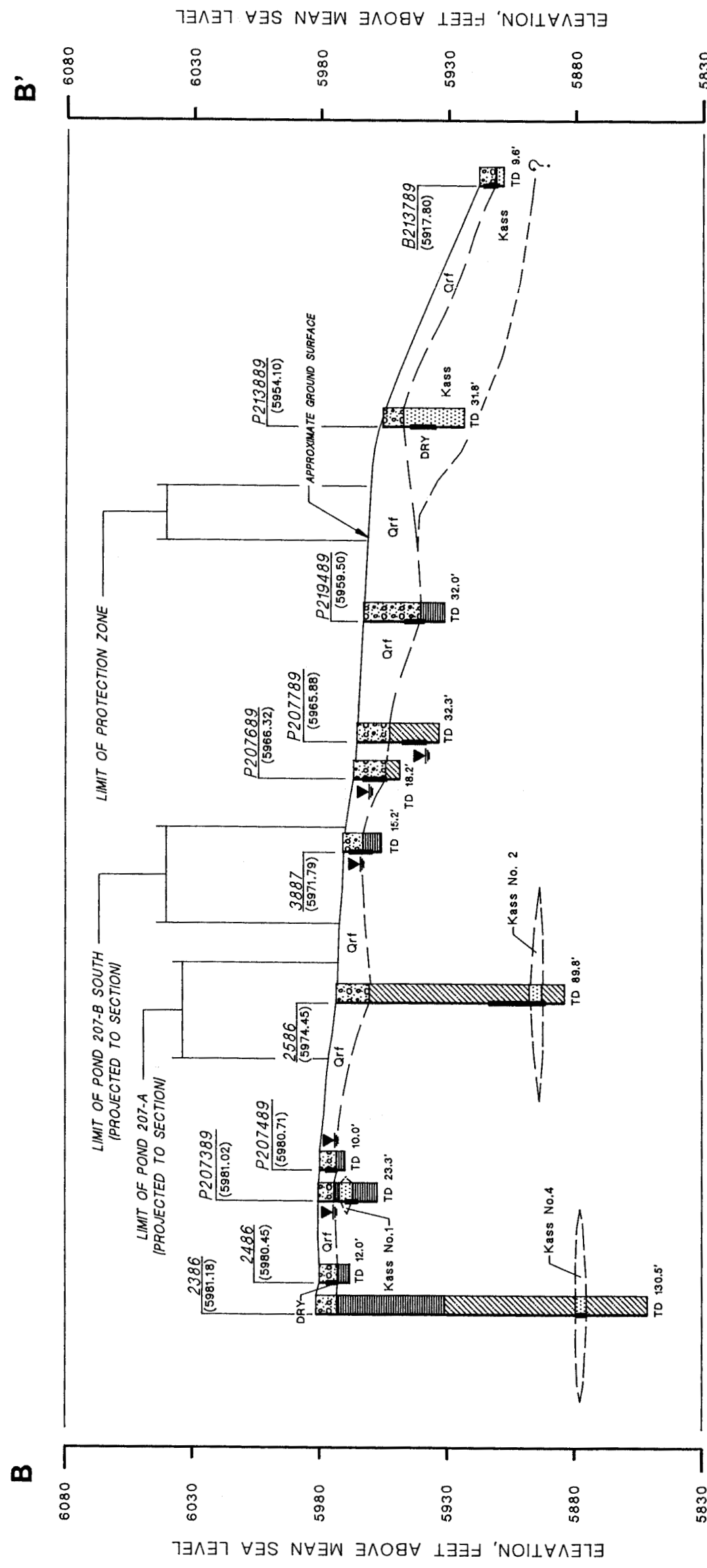
THE DEPTH AND THICKNESS OF THE SUBSURFACE STRATA INDICATED ON THE SECTIONS WERE GENERALIZED FROM INFORMATION ON ACTUAL SUBSURFACE CONDITIONS EXISTING ONLY AT THE LOCATION OF THE TEST BORINGS AND IT IS POSSIBLE THAT SUBSURFACE CONDITIONS BETWEEN THE TEST BORINGS MAY VARY FROM THOSE INDICATED.

3386 — WELL IDENTIFICATION
(5949.28) — GROUND SURFACE ELEVATION
— SCREENED INTERVAL
— WATER LEVEL - 7/90
1990 ANNUAL RCRA GROUNDWATER
MONITORING REPORT
EG&G RFEDs (DATA BASE)
TD 31.5' — TOTAL DEPTH DRILLED

PREPARED FOR: **EG&G ROCKY FLATS**
Rocky Flats Plant
Golden, Colorado
FIGURE 2-10

TITLE: **GEOLOGIC CROSS SECTION**
A - A'

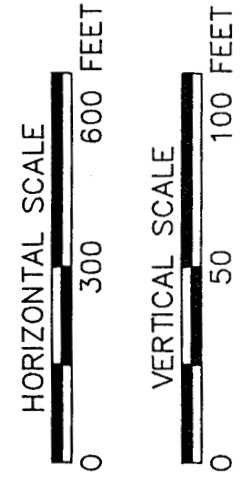
PROJ. NO.	304909	DWG. NO.	304909-B25	SHEET
DESIGN BY	C. DARR	CHECKED	G. BRAND	OF
DRAWN BY	C. BENTZ	APPROVED		
DATE	10/14/91	SCALE	AS SHOWN	



(LOOKING NORTH)

THE BORING LOGS AND RELATED INFORMATION
DEPICT SUBSURFACE CONDITIONS ONLY AT
THE SPECIFIC LOCATIONS AND DATES INDICATED.
SOIL CONDITIONS AND WATER LEVELS AT
OTHER LOCATIONS MAY DIFFER FROM CONDITIONS
OCCURRING AT THESE BORING LOCATIONS. ALSO
THE PASSAGE OF TIME MAY RESULT IN A
CHANGE IN THE CONDITIONS AT THESE
BORING LOCATIONS.

THE DEPTH AND THICKNESS OF THE SUBSURFACE STRATA
INDICATED ON THE SECTIONS WERE GENERALIZED FROM
AND INTERPOLATED BETWEEN THE TEST BORINGS.
INFORMATION ON ACTUAL SUBSURFACE CONDITIONS
EXISTS ONLY AT THE LOCATION OF THE TEST BORINGS
AND IT IS POSSIBLE THAT SUBSURFACE CONDITIONS
BETWEEN THE TEST BORINGS MAY VARY FROM THOSE
INDICATED.



LEGEND

QUATERNARY	
	GRAVEL
	ROCKY FLATS ALLUVIUM
CRETACEOUS	
	SANDSTONE
	ARAPAHOE SANDSTONE
	SILTY CLAYSTONE
	ARAPAHOE SILTY CLAYSTONE
	CLAYSTONE
	ARAPAHOE CLAYSTONE

3386 — WELL IDENTIFICATION
(5949.28) — GROUND SURFACE ELEVATION

— SCREENED INTERVAL

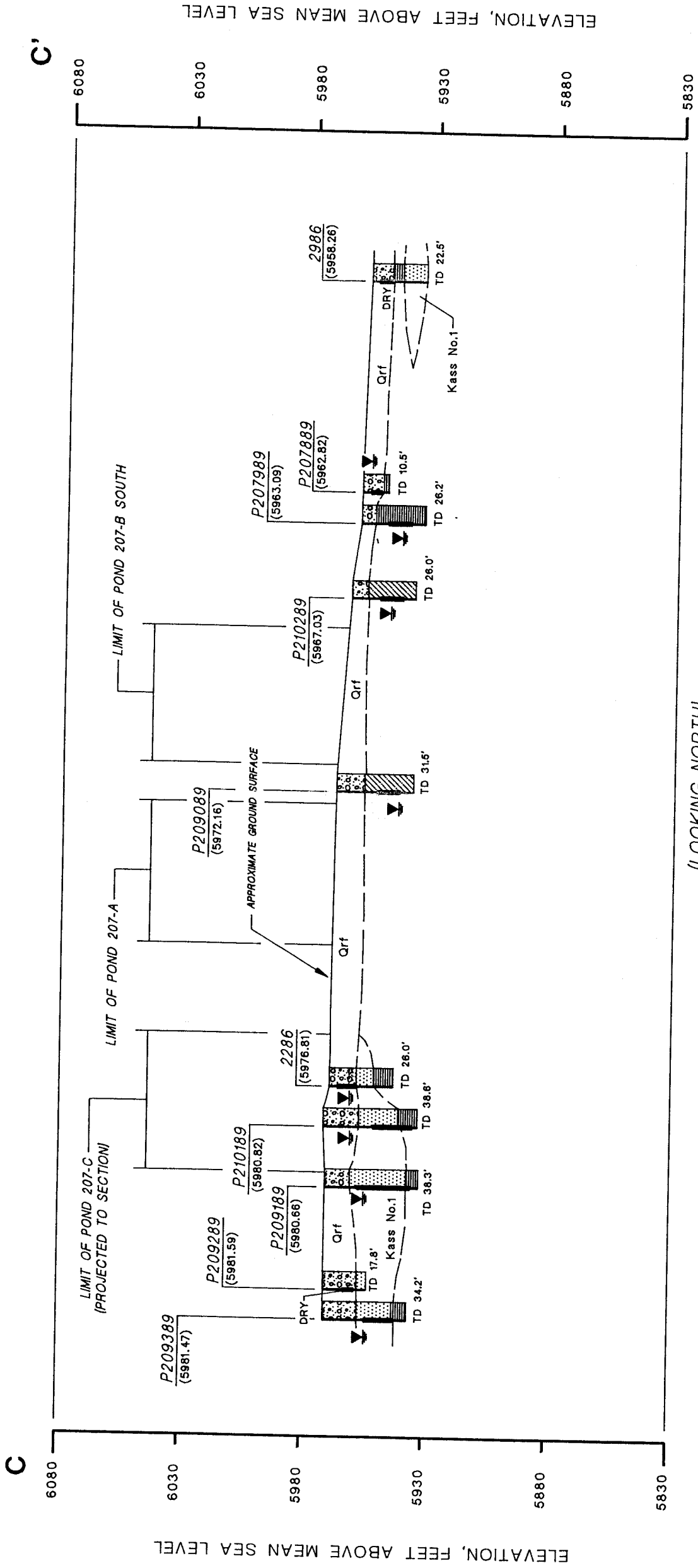
— WATER LEVEL - 7/90
1990 ANNUAL RCRA GROUNDWATER
MONITORING REPORT
EG&G RFEDs (DATA BASE)

TD 31.5' — TOTAL DEPTH DRILLED

PREPARED FOR:
EG&G ROCKY FLATS
Rocky Flats Plant
Golden, Colorado
FIGURE 2-11

TITLE:
**GEOLOGIC CROSS SECTION
B - B'**

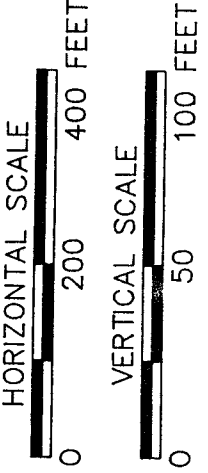
PROJ. NO.	304909	DWG. NO.	304909-B26	SHEET
DESIGN BY	C. DARR	CHECKED	G. BRAND	OF
DRAWN BY	C. BENTZ	APPROVED		
DATE	10/19/91	SCALE	AS SHOWN	



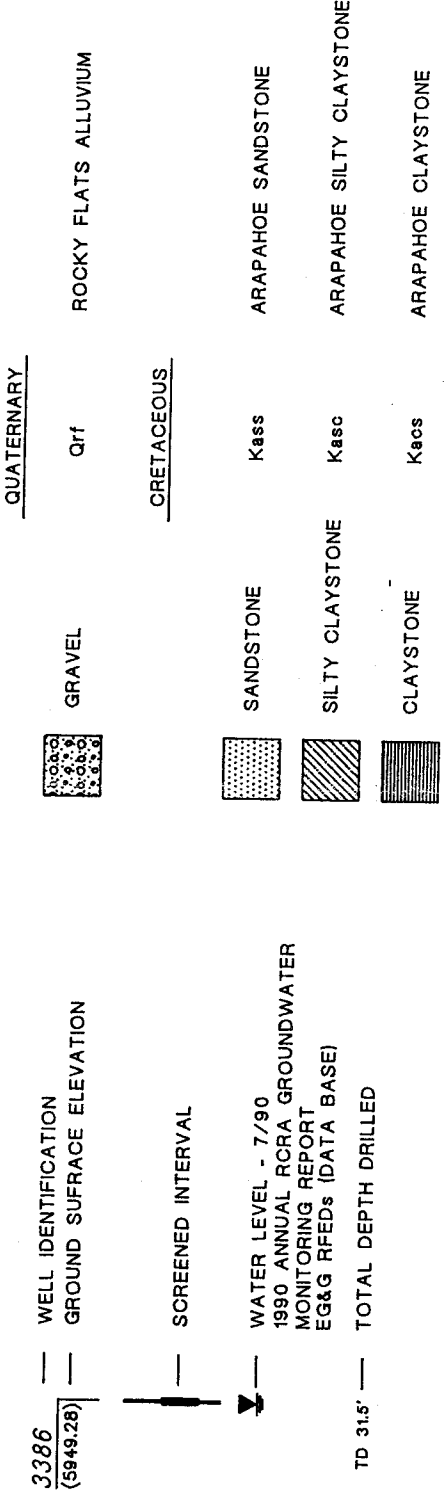
(LOOKING NORTH)

THE BORING LOGS AND RELATED INFORMATION
DEPICT SUBSURFACE CONDITIONS ONLY AT
THE SPECIFIC LOCATIONS AND DATES INDICATED.
SOLAR CONDITIONS AND WATER LEVELS AT
OTHER LOCATIONS MAY DIFFER FROM CONDITIONS
OCCURRING AT THESE BORING LOCATIONS. ALSO
THE PASSAGE OF TIME MAY RESULT IN A
CHANGE IN THE CONDITIONS AT THESE
BORING LOCATIONS.

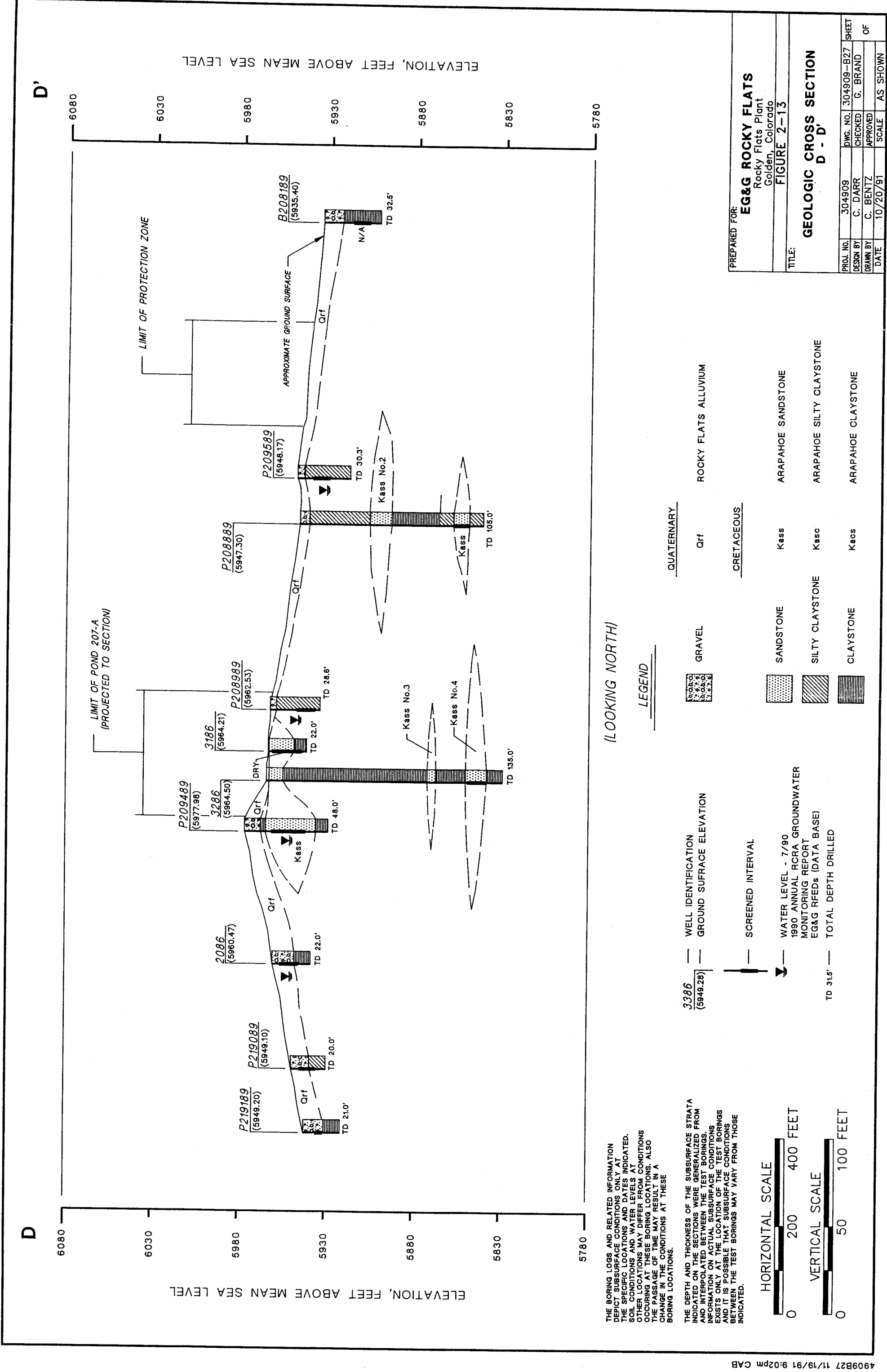
THE DEPTH AND THICKNESS OF THE SUBSURFACE STRATA
INDICATED ON THE SECTIONS WERE GENERALIZED FROM
AND INTERPOLATED BETWEEN THE TEST BORINGS.
INFORMATION ON ACTUAL SUBSURFACE CONDITIONS
EXISTS ONLY AT THE LOCATION OF THE TEST BORINGS
AND IT IS POSSIBLE THAT SUBSURFACE CONDITIONS
BETWEEN THE TEST BORINGS MAY VARY FROM THOSE
INDICATED.



LEGEND



PREPARED FOR:			
EG&G ROCKY FLATS			
Rocky Flats Plant			
Golden, Colorado			
FIGURE 2-12			
TITLE:			
GEOLOGIC CROSS SECTION			
C - C'			
PROJ. NO.	DWG. NO.	304909-B47	SHEET
DESIGN BY	C. DARR	CHECKED	G. BRAND
DRAWN BY	C. BENTZ	APPROVED	OF
DATE	10/20/91	SCALE	AS SHOWN



PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 2-14

PRELIMINARY BEDROCK GEOLOGY

PROJ. NO.	304800	DWG. NO.	304909-B48	SHEET OF
DESIGN BY		CHECKED	<i>HN/S</i>	
DRAWN BY	KRONER	APPROVED		
DATE	9-24-91	SCALE	1=300	

LEGEND

P218389 ALLUVIAL WELLS

Δ PRE-1986 WELLS

P209489 BEDROCK WELLS

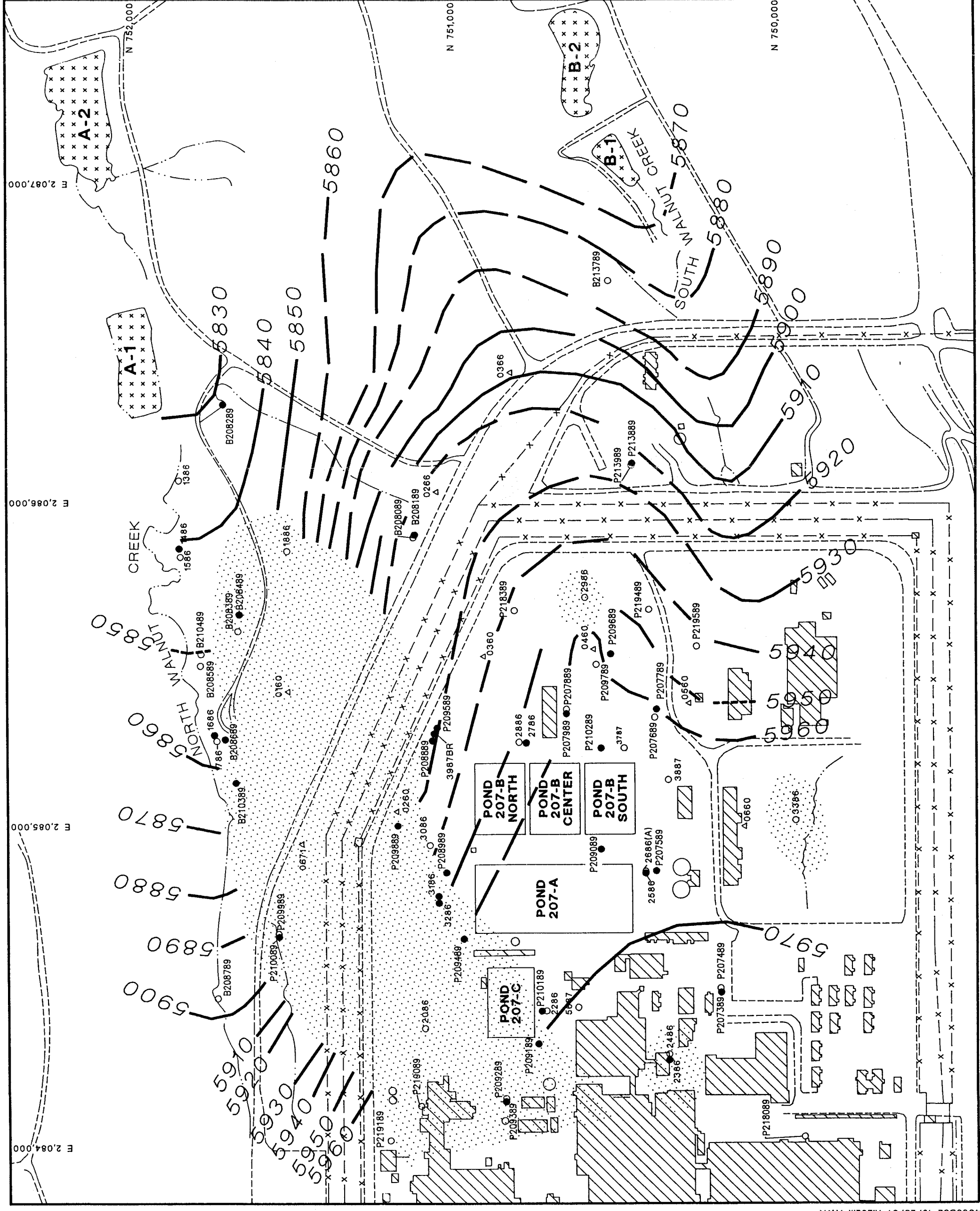
ROADS

DRAINAGE / STREAM

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U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

TITLE:
**WELL LOCATIONS IN SOLAR
EVAPORATION POND AREA**

PROJ. NO.	304909	DWG. NO.	304909-B24	SHEET OF
DESIGN BY	G. BRAND	CHECKED	<i>GB</i>	
DRAWN BY	KRONER	APPROVED		
DATE	9-24-91	SCALE	1=300	



LEGEND

- P218389
O
- P209489
A
- P209489
B
- ROADS
- DRAINAGE / STREAM
- LINE OF EQUAL POTENTIOMETRIC SURFACE (Feet above sea level)
DASHED WHERE APPROXIMATELY LOCATED (Contour Interval = 10 FT.)
- UNSATURATED MATERIALS (Reference: Modified after RCRA Annual Ground Water Monitoring 1990, Figure 2-2.)

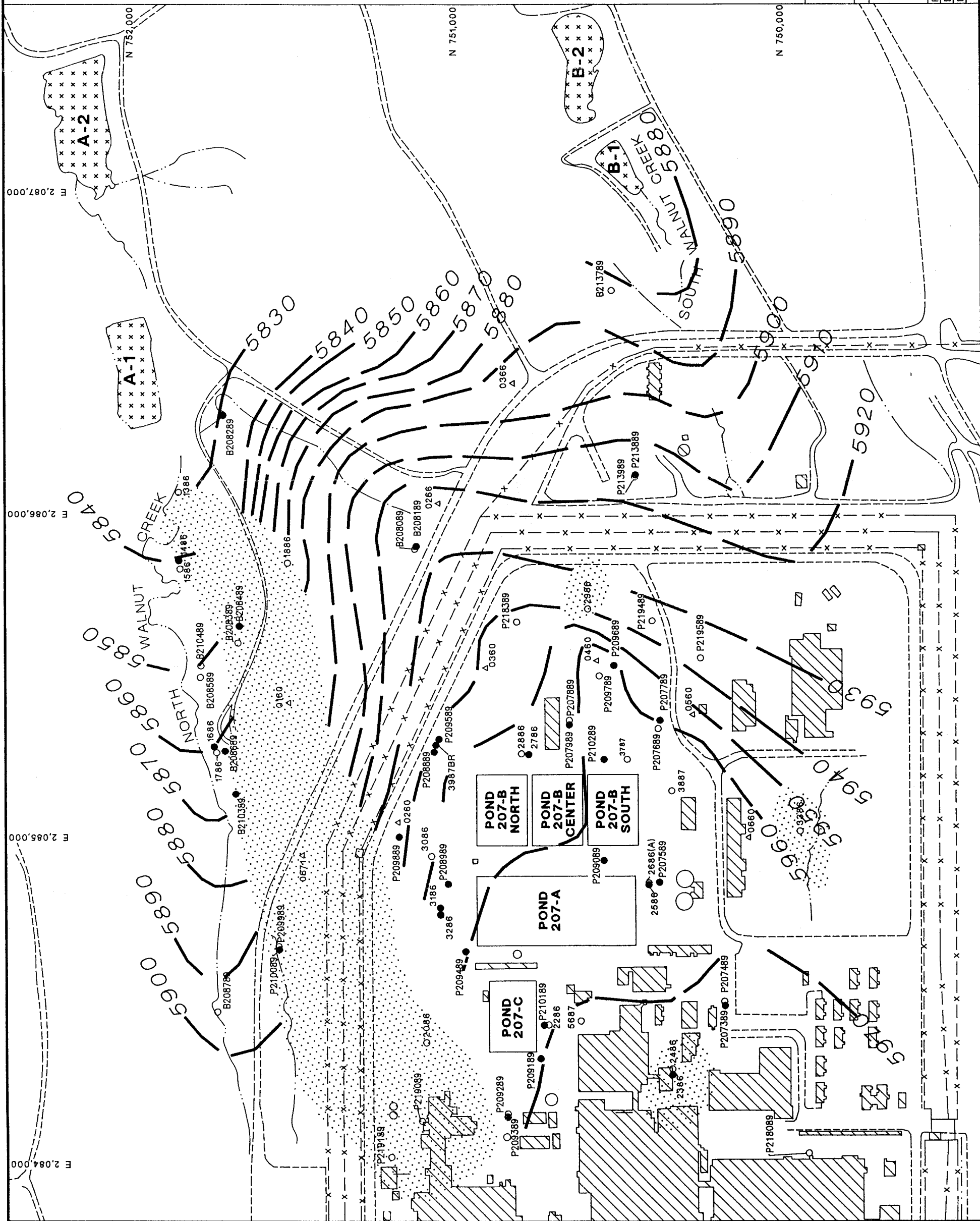


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Rocky Flats Plant
Golden, Colorado

FIGURE 2-16

TITLE: **POTENTIOMETRIC SURFACES IN SURFICIAL MATERIALS, FIRST QUARTER 1990 (FEBRUARY TO MARCH)**

PROJ. NO.	DWG. NO.	SHEET
304909	304909-B32	1
DESIGN BY	CHECKED	OF
DRAWN BY	KRONER	1-300
DATE	10-15-91	



LEGEND

ALLUVIAL WELLS

P218389
O

PRE-1986 WELLS

Δ
0360

BEDROCK WELLS

P209489 •

ROADS

1	1
1	1
1	1
1	1
1	1

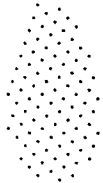
DRAINAGE / STREAM

!

LINE OF EQUAL
POTENTIOMETRIC SURFACE
(Feet above sea level)
DASHED WHERE
APPROXIMATELY LOCATED
(Contour interval = 10 FT.)

—5860

UNSATURATED MATERIALS
Reference: Modified
after RCRA Annual
Ground Water Monitoring
Report 1990,
Figure 2-3.)



A horizontal scale bar with the word "SCALE" written vertically above it. The bar has three major tick marks labeled "0", "300", and "600 FEET" from left to right.

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U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 2-17

POTENTIOMETRIC SURFACE IN
SURFICIAL MATERIALS,
THIRD QUARTER 1990
(AUGUST)

PROJ. NO.	304909	DWG. NO.	304909-B33	SHEET OF
DESIGN BY		CHECKED		
DRAWN BY		APPROVED		
DATE	10-15-91	SCALE	1=300	

LEGEND

ALLUVIAL WELLS

P218389

PRE-1986 WELLS

Δ

BEDROCK WELLS

P209489

ROADS

1	1
1	1
1	1
1	1
1	1

DRAINAGE / STREAM

— — — — —

LINE OF EQUAL
POTENTIOMETRIC SURFACE
(Feet above sea level)
DASHED WHERE
APPROXIMATELY LOCATED
(Contour interval = 10 FT.)

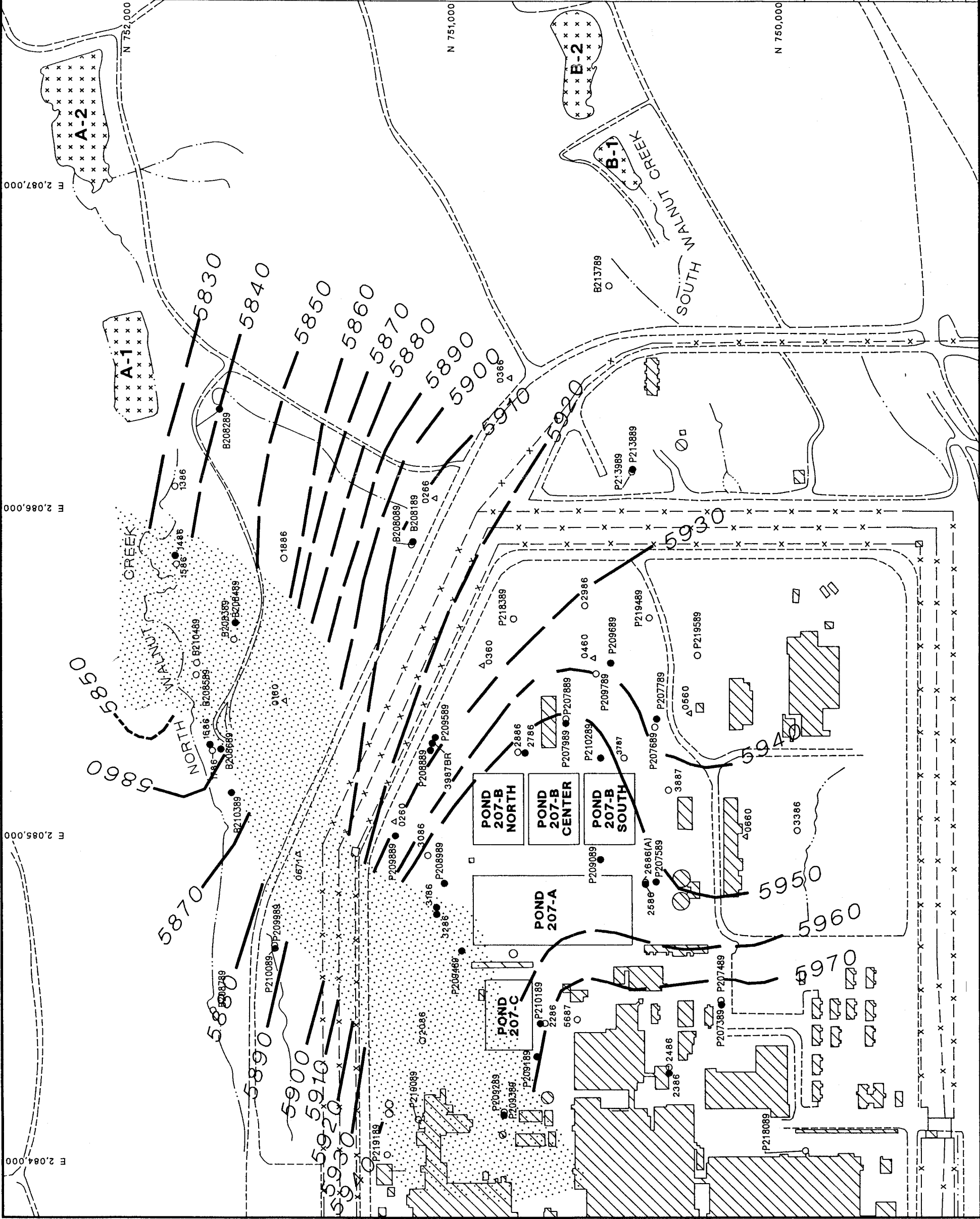
0985

UNSATURATED MATERIALS
(Reference: Modified
after RCRA Annual
Ground Water Monitoring
Report 1990,
Figure 2-4.)

PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

**TITLE: POTENTIOMETRIC SURFACE IN
WEATHERED BEDROCK
FIRST QUARTER 1990
(FEBRUARY TO MARCH)**

PROJ. NO.	304909	DWG. NO.	304909-B34	SHEET OF
DESIGN BY		CHECKED	<i>HN/B</i>	
DRAWN BY	KRONER	APPROVED		
DATE	10-15-91	SCALE	1=300	



LEGEND

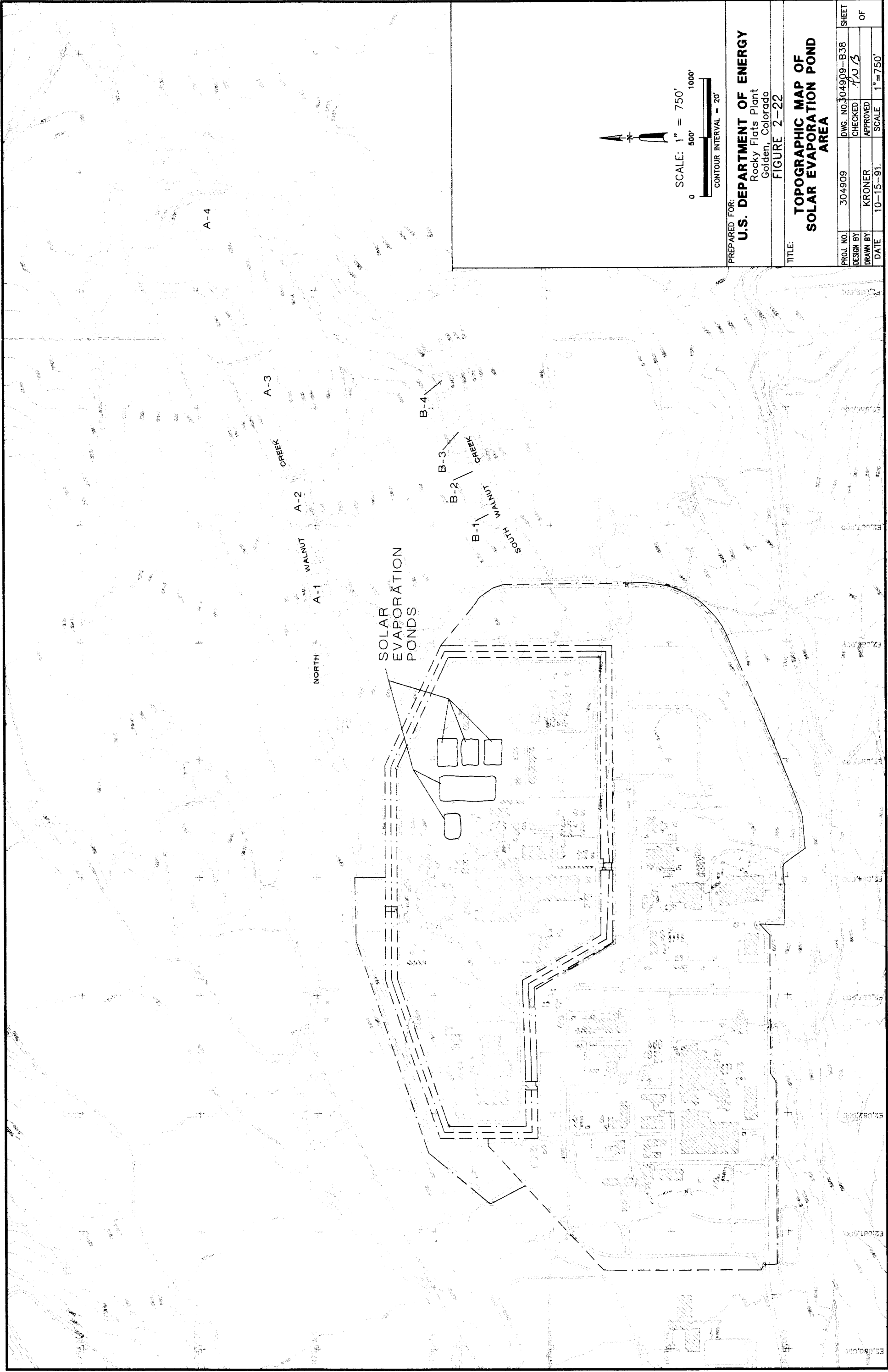
- P218389
O ALLUVIAL WELLS
- A 0360
PRE-1986 WELLS
- P209489
BEDROCK WELLS
- ROADS
- DRAINAGE / STREAM
- LINE OF EQUAL POTENTIOMETRIC SURFACE (Feet above sea level)
DASHED WHERE APPROXIMATELY LOCATED (Contour Interval = 10 FT.)
- UNSATURATED MATERIALS (Reference: Modified after RCRA Annual Ground Water Monitoring Report 1990, Figure 2-5.)



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Rocky Flats Plant
Golden, Colorado

TITLE: **POTENTIOMETRIC SURFACE IN
WEATHERED BEDROCK
THIRD QUARTER 1990
(AUGUST)**
FIGURE 2-20

PROJ. NO.	304909	DWG. NO.	304909-B35	SHEET
DESIGN BY	KRONER	CHECKED	ANB	OF
DRAWN BY	KRONER	APPROVED		
DATE	10-15-91	SCALE	1=300	



PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 2-22

**TOPOGRAPHIC MAP OF
SOLAR EVAPORATION POND
AREA**

PROJ. NO.	304909	DWG. NO.	304909-B38	SHEET
DESIGN BY		CHECKED	HJ	OF
DRAWN BY	KRONER	APPROVED		
DATE	10-15-91	SCALE	1"=750'	

The map displays a study area with several sampling locations marked by black dots. The locations are labeled as follows:

- P208389**: Located in the upper left quadrant.
- SP15-87**: Located in the lower left quadrant.
- 1886**: Located in the lower center.
- 1989 SOIL BORINGS**: Located in the upper left, near P208389.
- 1987 SOIL BORINGS**: Located in the lower left, near SP15-87.
- 1986 SOIL BORINGS**: Located in the lower center, near 1886.
- ROADS**: Located in the center-right area.
- DRAINAGE / STREAM**: Located in the lower right area.

The map also shows a network of roads and a drainage/stream system. A scale bar at the bottom indicates distances in meters (0, 100, 200, 300, 400, 500).



A horizontal scale bar with the word "SCALE" written vertically above it. The bar has three segments marked with vertical lines. Below the bar, the numbers "0", "300", and "600 FEET" are written from left to right, corresponding to the segments.

PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 2-23

TABLE:

SOIL BORING LOCATIONS

PROJ. NO.	304900	DWG. NO.	304909-B30	SHEET OF
DESIGN BY	B. NEARY	CHECKED	B. NEARY	
DRAWN BY	BENTZ	APPROVED		
DATE	10-11-91	SCALE	1=300	

E 2,084,000

E 2,085,000

E 2,086,000

E 2,087,000

N 752,000

N 751,000

N 750,000

LEGEND

- 1989 SOIL BORINGS
- 1987 SOIL BORINGS
- 1986 SOIL BORINGS
- ROADS
- DRAINAGE / STREAM

BOREHOLE NUMBER
DEPTH OF SAMPLE FEET
NITRATE/NITRITE CONCENTRATION RANGE (mg/kg)

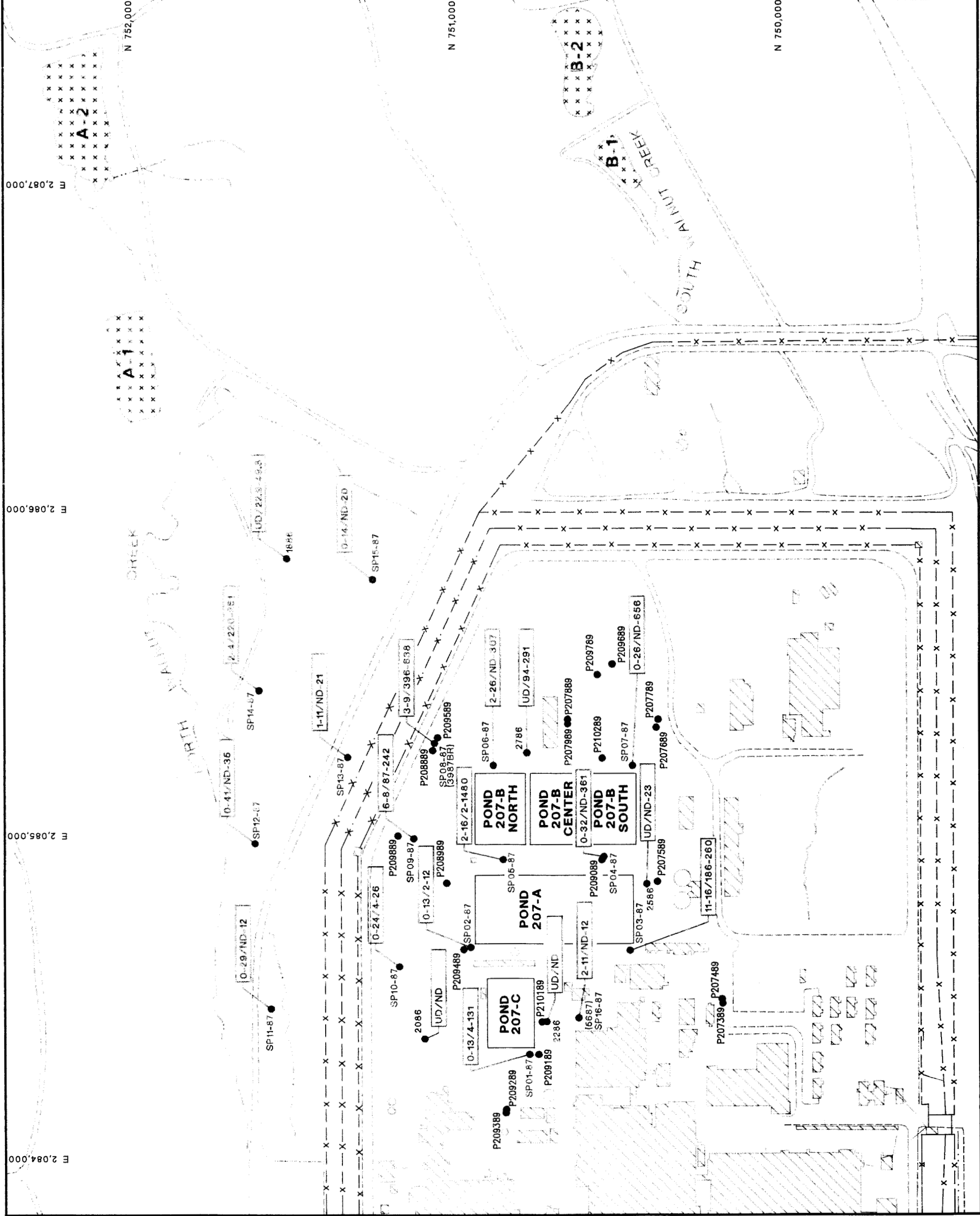


SCALE
0 300 600 FEET

PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado
FIGURE 2-24

NITRATE/NITRITE CONCENTRATION RANGES IN 1989 SOIL BORINGS

PROJ. NO.	DWG. NO.	304909-B50	SHEET
DESIGN BY	CHECKED	B. NEARY	12/3
DRAWN BY	APPROVED	BENTZ	OF
DATE	SCALE	10-21-91	1-300



LEGEND

- 1989 SOIL BORINGS
- 1987 SOIL BORINGS
- 1986 SOIL BORINGS
- ROADS
- DRAINAGE / STREAM

SP16-87
BOREHOLE NUMBER

0-14
DEPTH OF SAMPLE FEET

/ND-20
NITRATE/NITRATE CONCENTRATION RANGE (mg/kg)

ND = NOT DETECTED
UD = UNKNOWN SAMPLE DEPTHS
* IN 1986 BORINGS, ND = 20 mg/kg

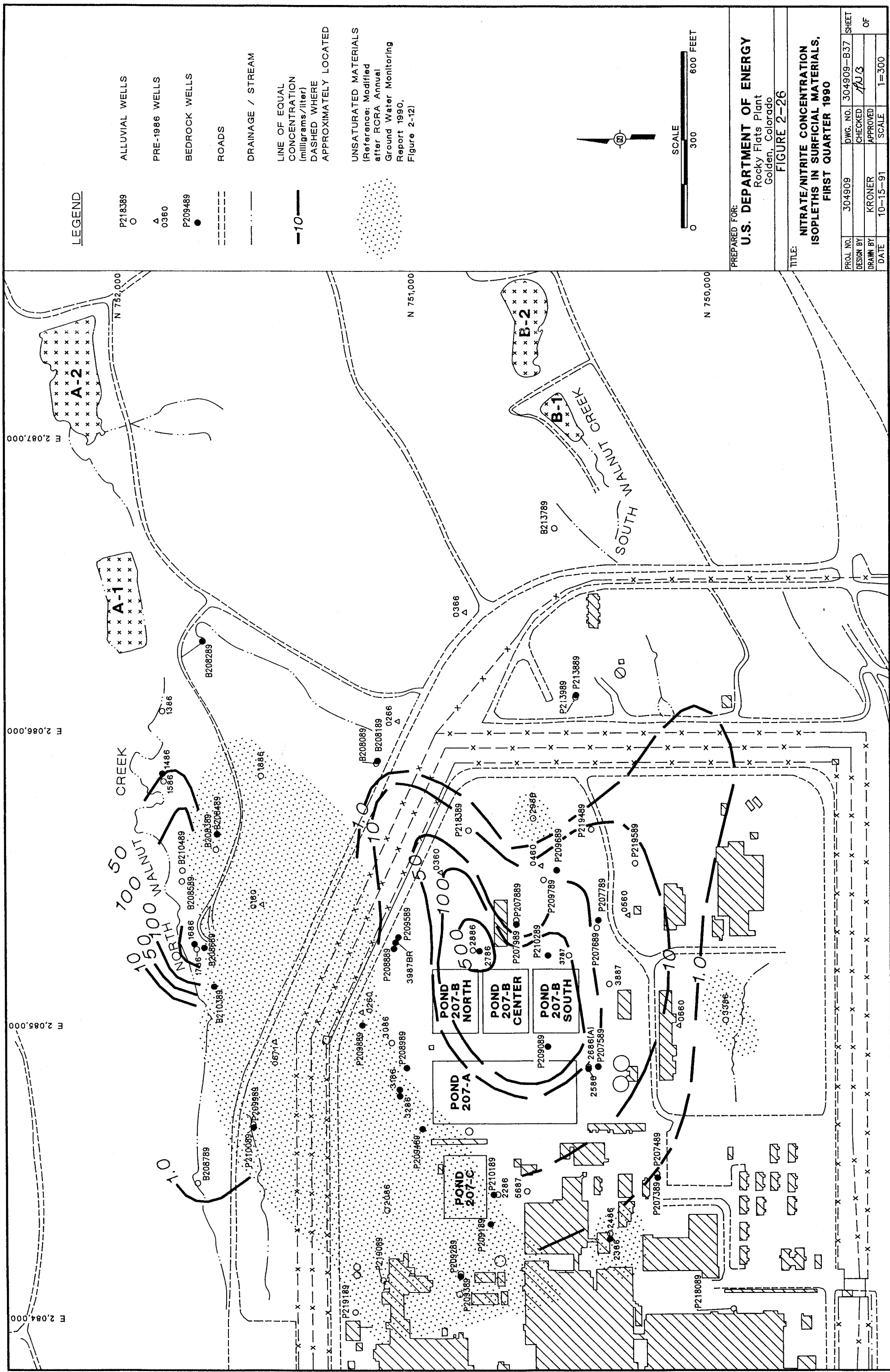


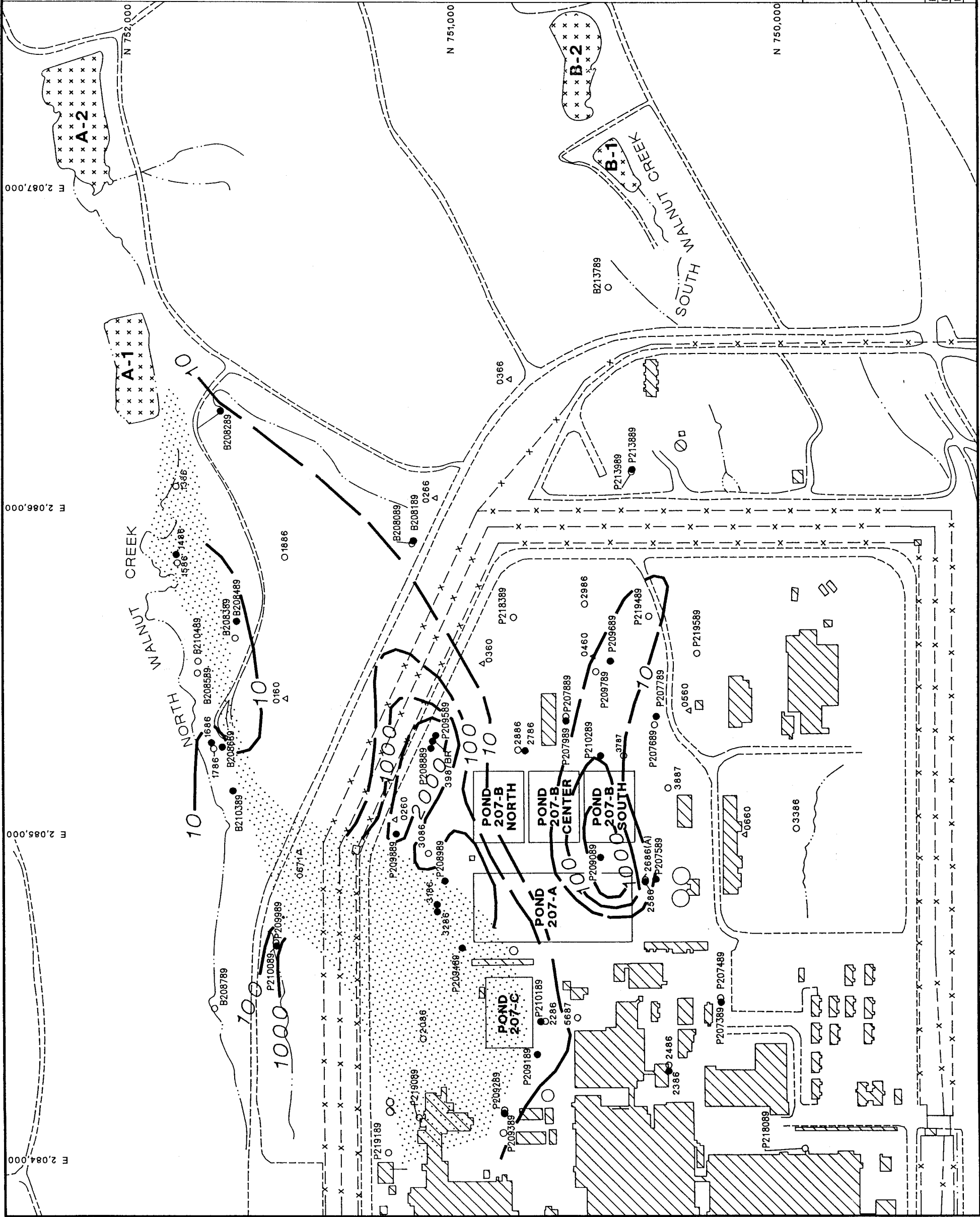
SCALE
0 300 600 FEET

PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

TITLE:
NITRATE/NITRITE CONCENTRATION RANGES IN HISTORICAL SOIL PROGRAMS

PROJ. NO.	304909	DWG. NO.	304909-B49	SHEET
DESIGN BY	B. NEARY	CHECKED	4/2/83	OF
DRAWN BY	BENTZ	APPROVED		
DATE	10-21-91	SCALE	1=300	





LEGEND

ALLUVIAL WELLS

P218389
○

PRE-1986 WELLS

△
0360

BEDROCK WELLS

P209489
●

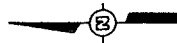
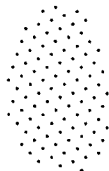
ROADS

DRAINAGE / STREAM

LINE OF EQUAL
CONCENTRATION
(milligrams/liter)
DASHED WHERE
APPROXIMATELY LOCATED

---10---

UNSATURATED MATERIALS
(Reference: Modified
after RCRA Annual
Ground Water Monitoring
Report 1990,
Figure 2-13.)



SCALE
0 300 600 FEET

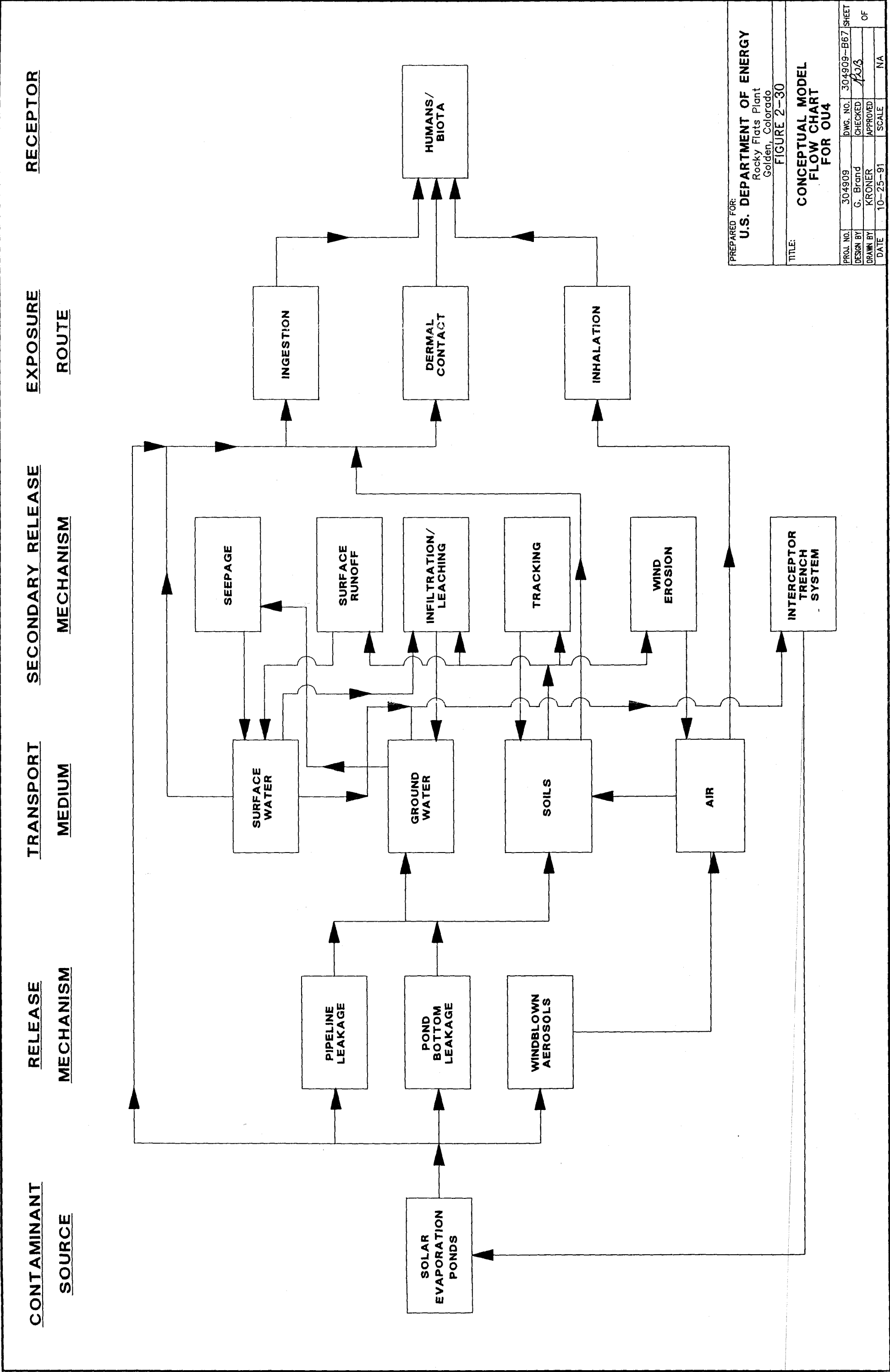
PREPARED FOR:

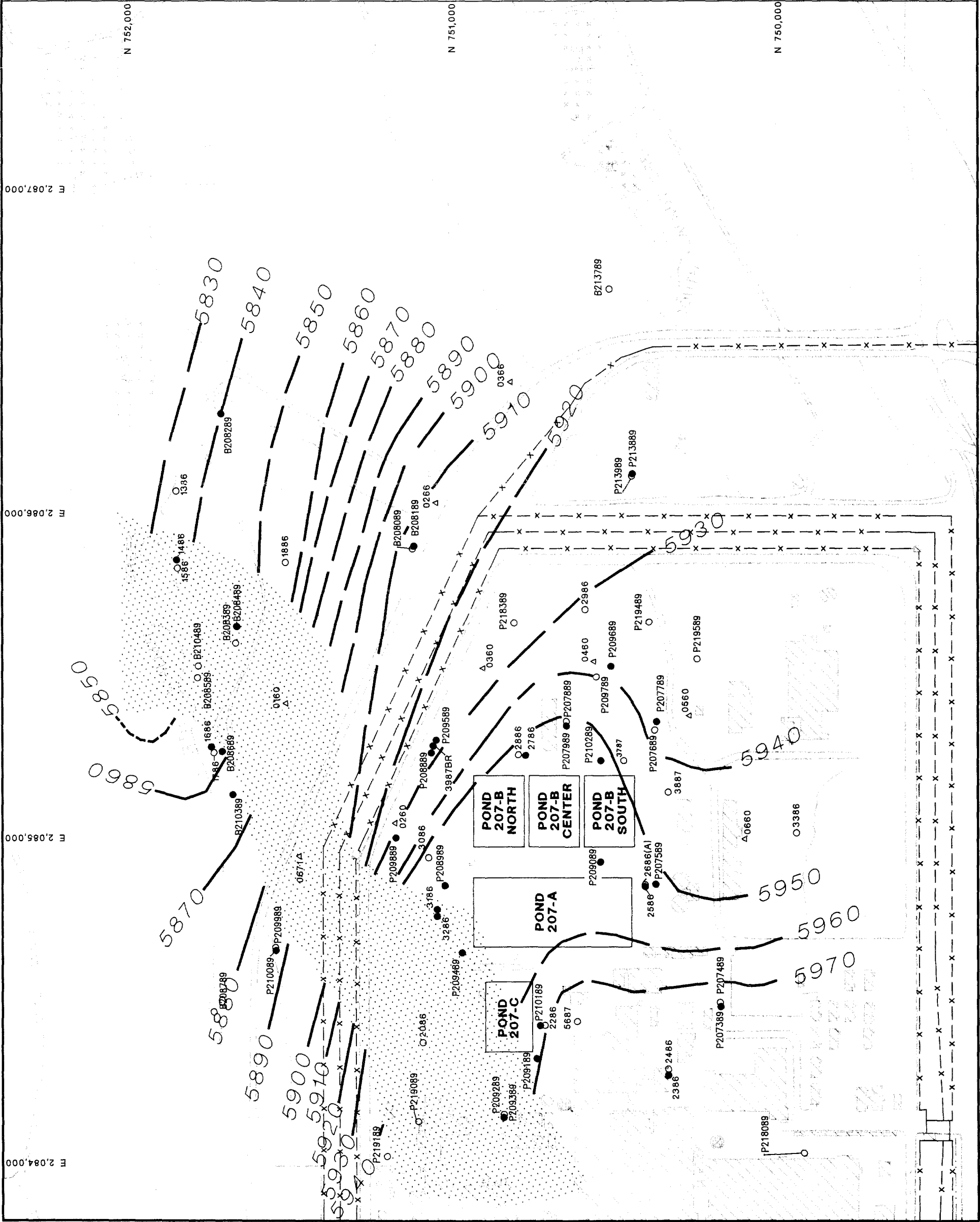
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 2-27

TITLE:
**NITRATE/NITRITE CONCENTRATION
ISOPLETHS IN WEATHERED BEDROCK,
FIRST QUARTER 1990**

PROJ. NO.	DWG. NO.	SHEET
304909	304909-B36	71A
DESIGN BY	CHECKED	OF
DRAWN BY	KRONER	APPROVED
DATE	10-15-91	SCALE 1=300





LEGEND

ALLUVIAL WELLS

PRE-1986 WELLS

BEDROCK WELLS

ROADS

DRAINAGE / STREAM

LINE OF EQUAL
POTENTIOMETRIC SURFACE
(Feet above sea level)
DASHED WHERE
APPROXIMATELY LOCATED
(Contour Interval = 10 FT.)

UNSATURATED MATERIALS
(Reference: Modified
after RCRA Annual
Ground Water Monitoring
Report 1990,
Figure 2-5.)

**PROPOSED LOCATION
OF MONITORING WELL
CLUSTER**
Each cluster will include
one well screened in alluvial
ground water system, one in
weathered bedrock, system and
one in unweathered bedrock

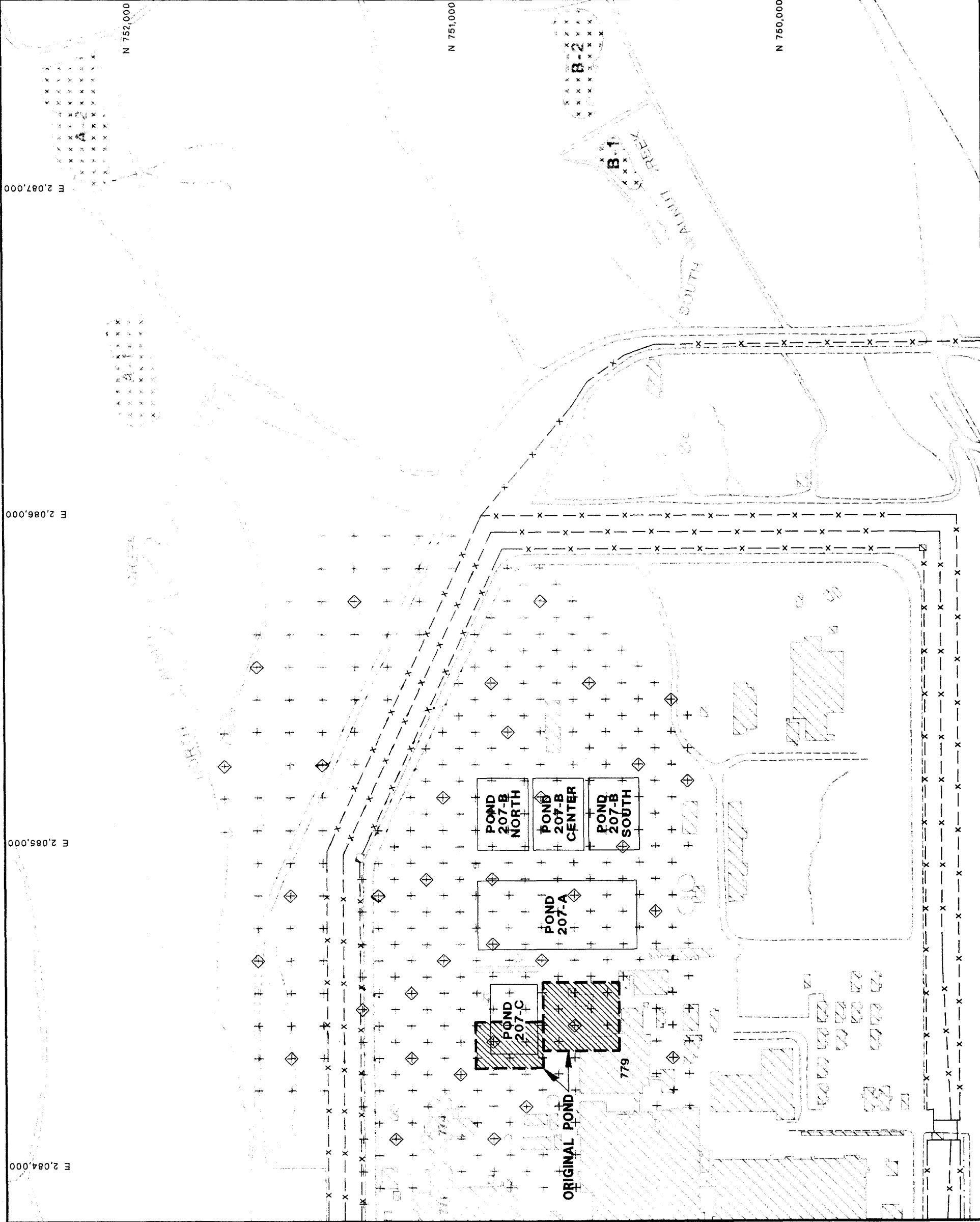


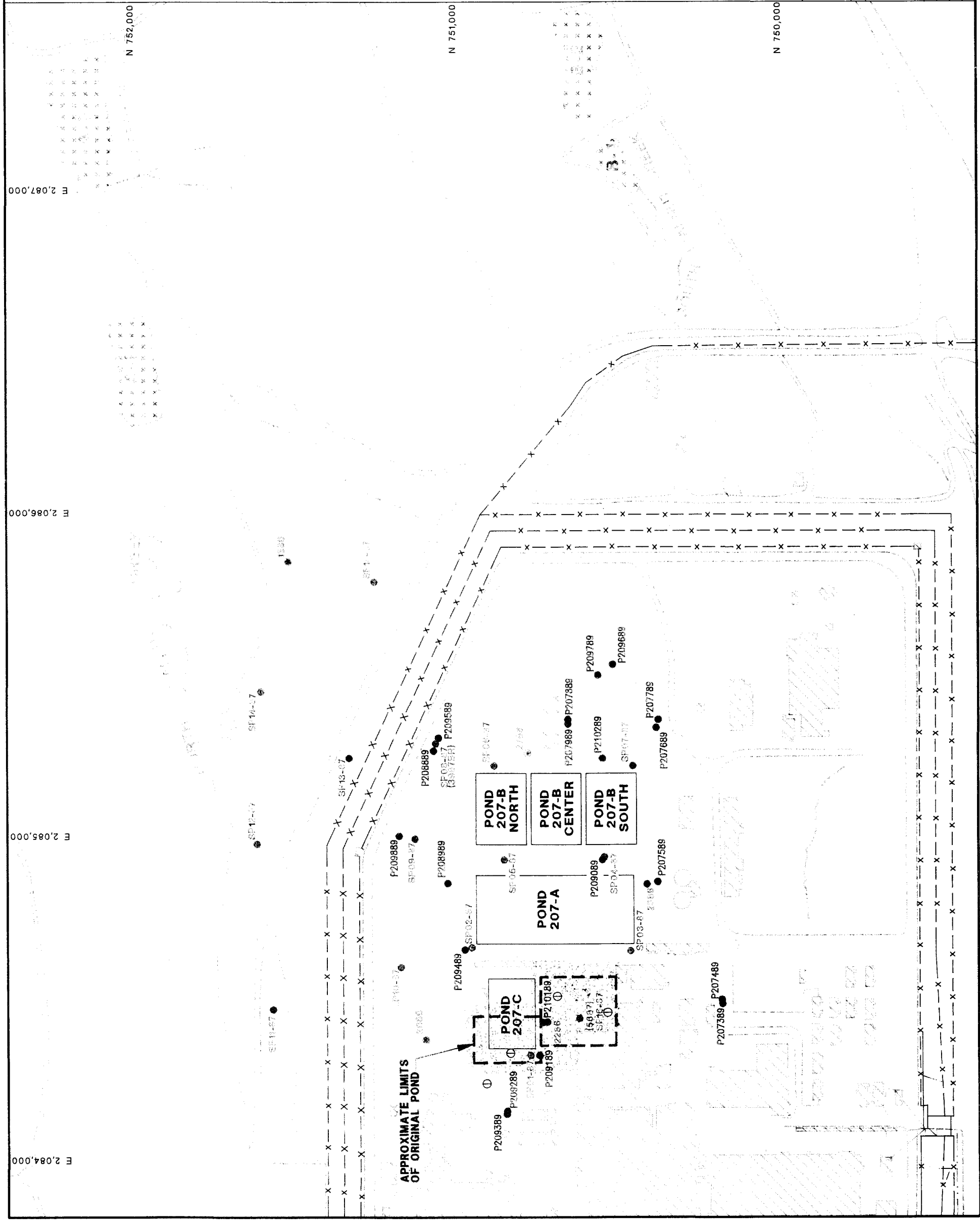
PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 7-1

**PROPOSED
UPGRADIENT MONITORING
WELL LOCATION
MAP**

PROJ. NO.	304909	DWG. NO.	304909-B56	SHEET OF
DESIGN BY	B. Neary	CHECKED	G. Brand	
DRAWN BY	KRONER	APPROVED		
DATE	10-23-91	SCALE	1=300	





LEGEND

685807.d

1989 SOIL BORINGS

35-15-07

1987 SOIL BORINGS

1892

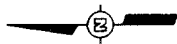
1986 SOIL BORINGS

ROADS


DRAINAGE / STREAM

① PROPOSED UNCONSOLIDATED
MATERIAL BOREHOLE LOCATIONS

PROPOSED AREA OF SURFACE
GEOPHYSICAL SURVEY TO
LOCATE ORIGINAL POND AND
BURIED PIPING



SCALE



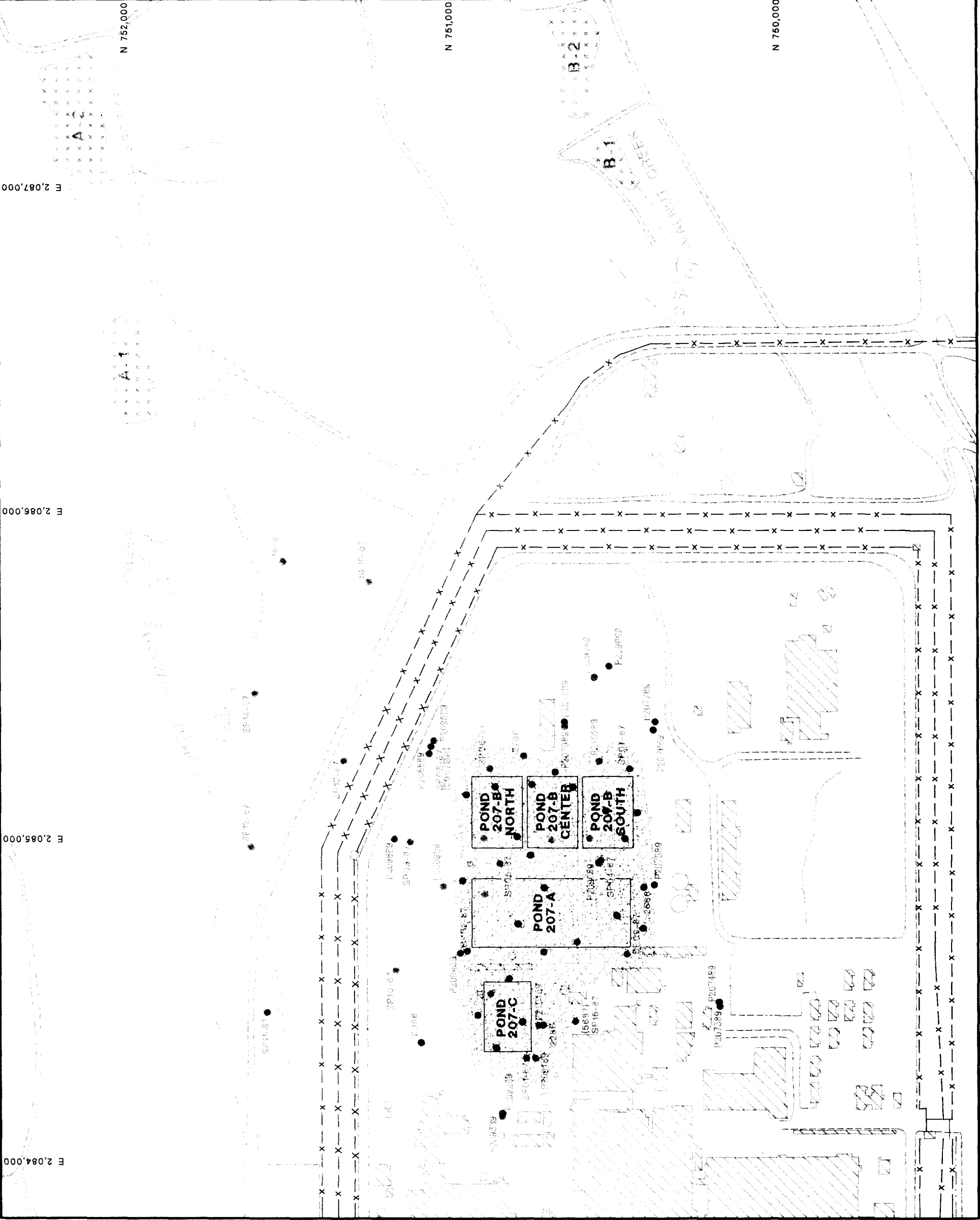
0 300 600 FEET

PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado
FIGURE 7-3

TITLE:

FIELD SAMPLING AND GEOPHYSICAL INVESTIGATION IN ORIGINAL POND AREA

PROJ. NO.	304909	DWG. NO.	304909-B60	SHEET OF
DESIGN BY	B. NEARY	CHECKED	<i>PLB</i>	
DRAWN BY	BENTZ	APPROVED		
DATE	10-11-91	SCALE	1=300	



LEGEND

- 1989 SOIL BORINGS
- 1987 SOIL BORINGS
- 1986 SOIL BORINGS
- ROADS
- DRAINAGE / STREAM
- UNCONSOLIDATED MATERIALS SAMPLING AT LINER CRACK LOCATION
- UNCONSOLIDATED MATERIALS SAMPLING AT INTACT LINER LOCATION
- UNCONSOLIDATED MATERIALS SAMPLING AT POND PERIMETERS
- GEOPHYSICAL SURVEY FOR SUBSURFACE PIPING

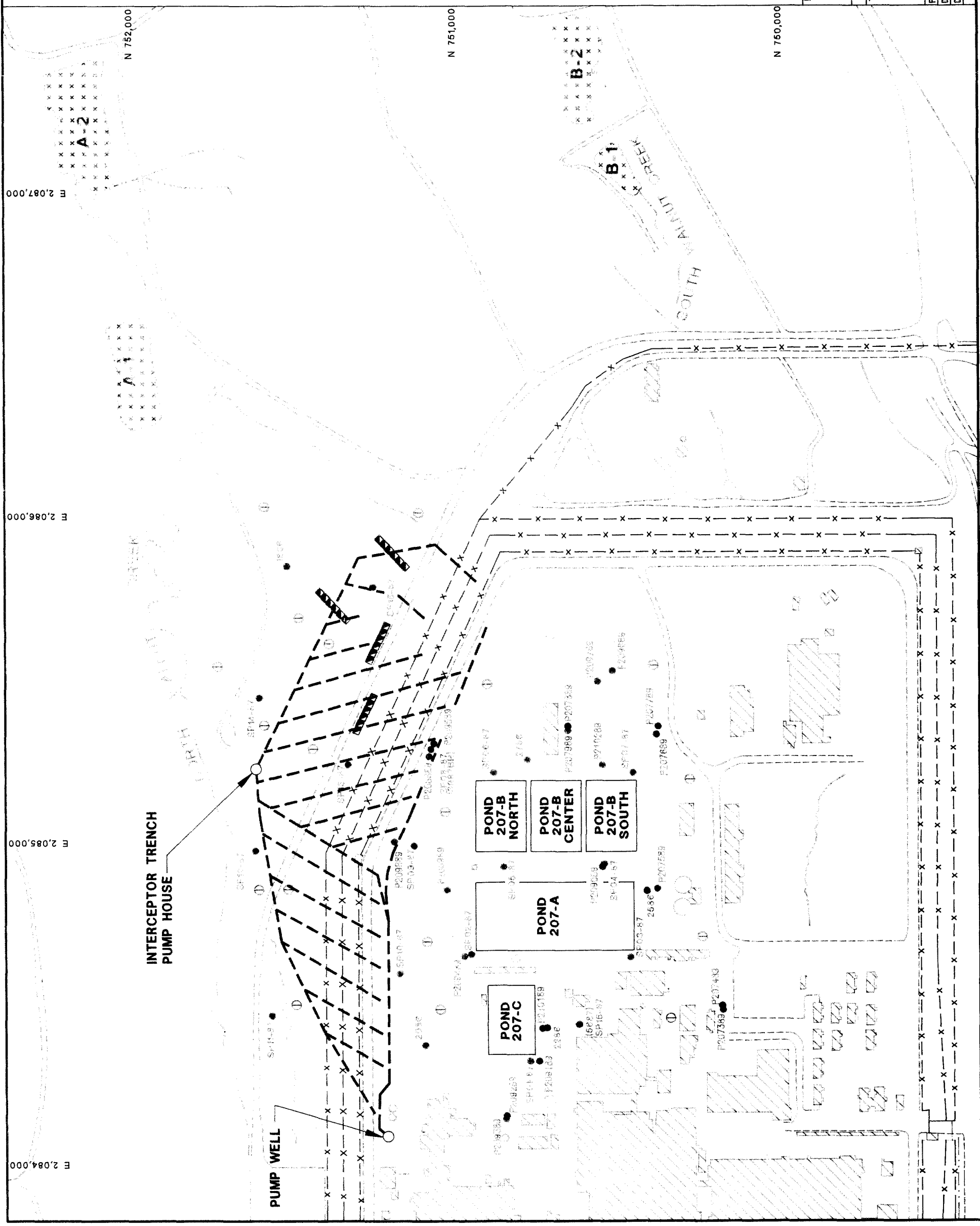


PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 7-4

TITLE:
**FIELD SAMPLING AND
GEOPHYSICAL INVESTIGATION
AT EXISTING
SOLAR EVAPORATION PONDS**

PROJ. NO.	304909	DWG. NO.	304909-B59	SHEET
DESIGN BY	B. NEARY	CHECKED BY	B. NEARY	OF
DRAWN BY	BENTZ	APPROVED	XX	
DATE	10-23-91	SCALE	1=300	



LEGEND

- 1989 SOIL BORINGS
- 1987 SOIL BORINGS
- 1986 SOIL BORINGS
- ROADS
- DRAINAGE / STREAM
- PROPOSED PIEZOMETER LOCATIONS
- PROPOSED UNCONSOLIDATED MATERIAL BOREHOLE LOCATIONS

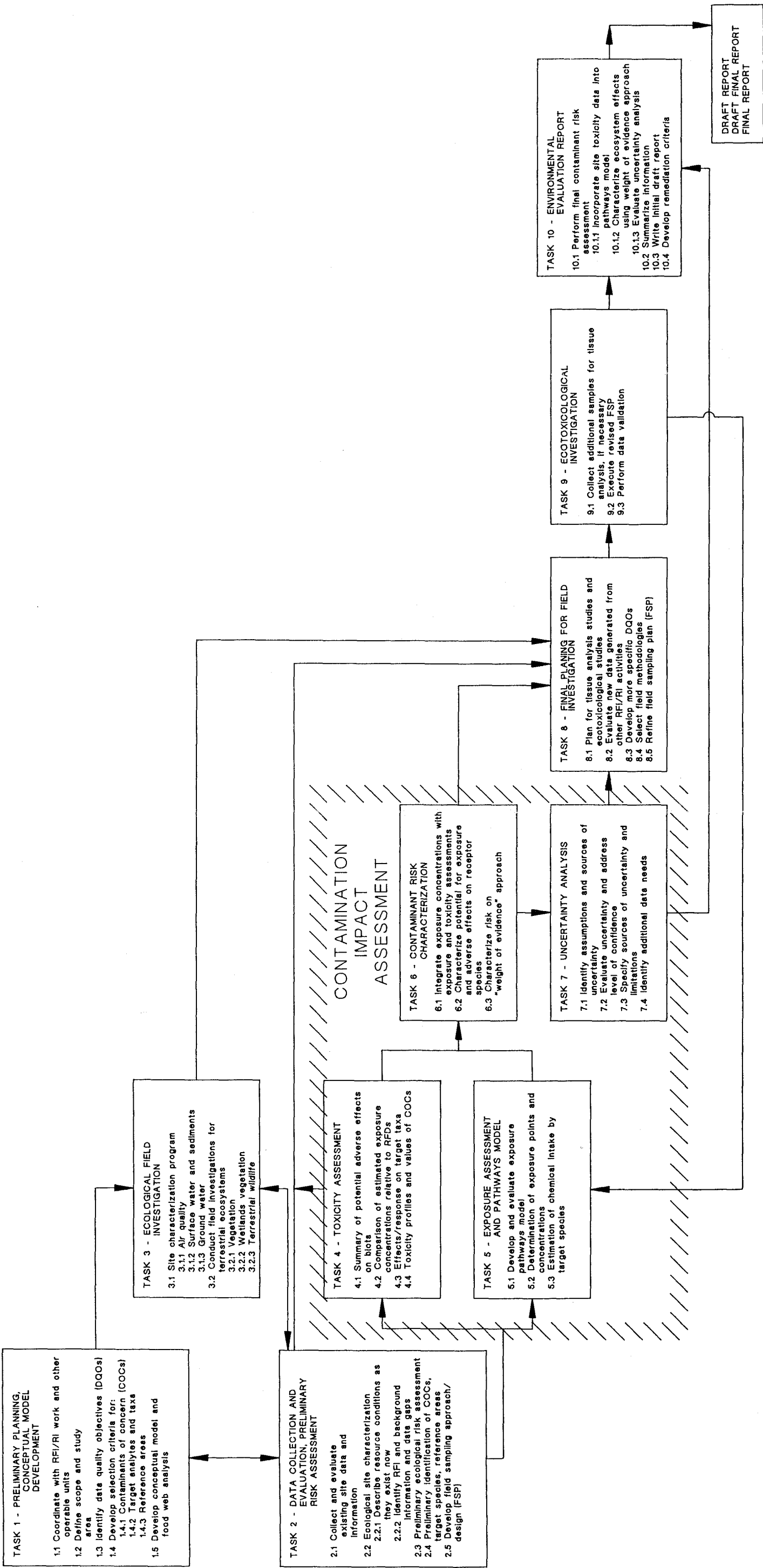


PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 7-5

TITLE:
FIELD SAMPLING AND GEOPHYSICAL INVESTIGATION IN INTERCEPTOR TRENCH SYSTEM AND REMAINING AREAS

PROJ. NO.	304909	DWG. NO.	304909-B58	SHEET
DESIGN BY	B. NEARY	CHECKED		OF
DRAWN BY	BENTZ	APPROVED		
DATE	10-23-91	SCALE	1=300	



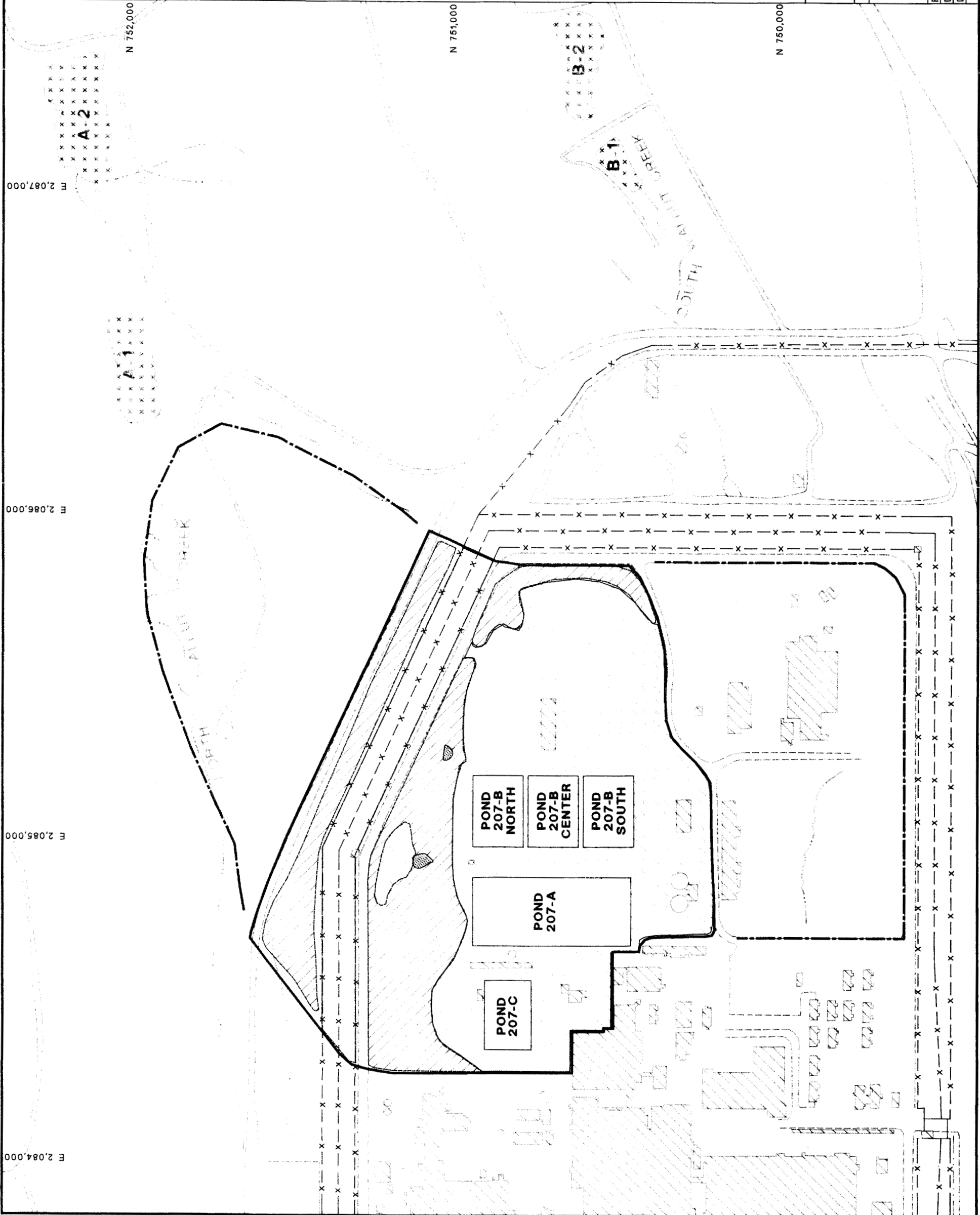
PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

TITLE:
FIGURE 9-1

OPERABLE UNIT 4
PHASE I RFI/RI WORK PLAN

**FLOW DIAGRAM:
INTERRELATIONSHIPS BETWEEN TASKS
IN ENVIRONMENTAL EVALUATION**

PROJ. NO.	DWG. NO.	CHECKED	BY	DATE	SCALE	SHEET
304909	304909-B40	G. BRAND	I. HANNE	10/15/91	NA	OF
DESIGN BY	APPROVED		R. HYNA			
DRAWN BY						



LEGEND

- ROADS
- DRAINAGE / STREAM
- PRELIMINARY STUDY AREA
- AREA OF OVERLAP WITH OTHER OU'S
- SEEP AREAS (SUPPORTING WET MEADOWS TYPE VEGETATION)
- MIXED GRASSLAND COMMUNITY TYPE
- DISTURBANCE/BARREN LAND OR CHEATGRASS/WEEDY FORBS COMMUNITY TYPE



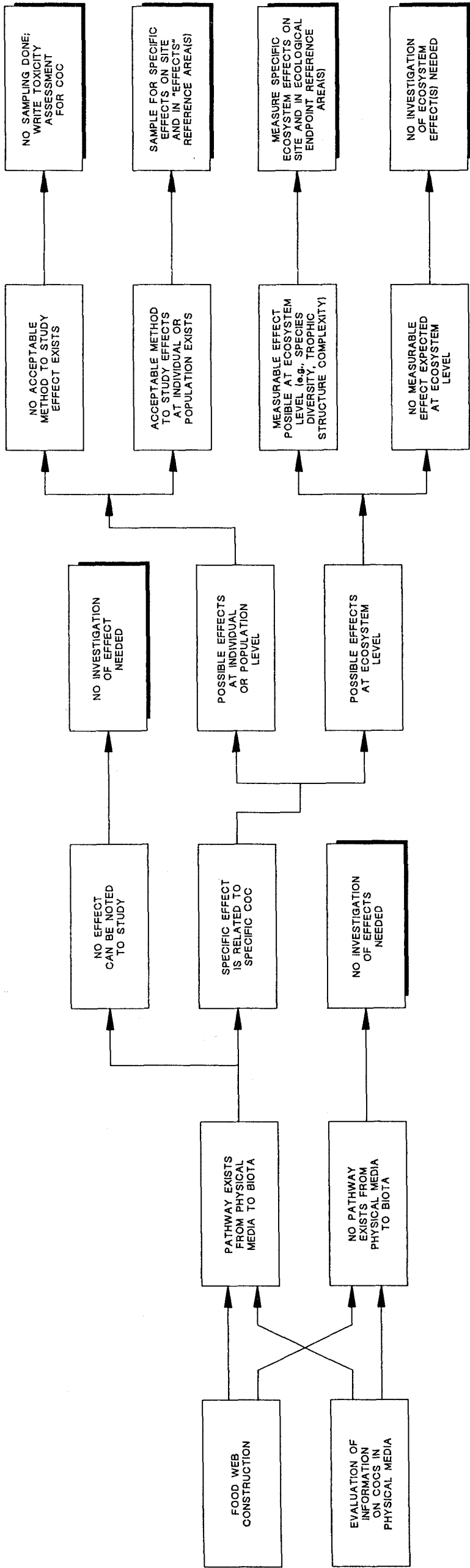
PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 9-2

TITLE:

HABITATS WITHIN THE OU4 AREA

PROJ. NO.	304909	DWG. NO.	304909-B44	SHEET
DESIGN BY	I. HANINE	CHECKED	G. BRAND	OF
DRAWN BY	KRONER	APPROVED		
DATE	10-16-91	SCALE	1=300	

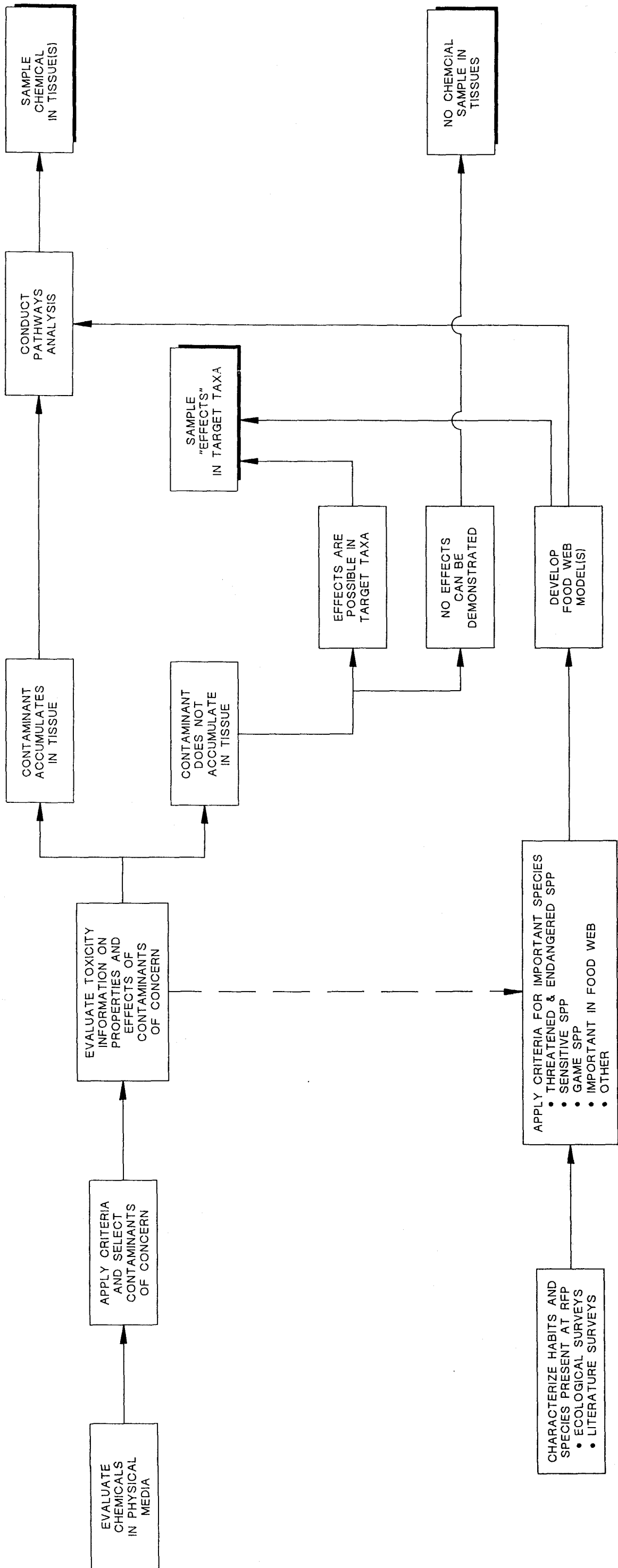


PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 9-3
OPERABLE UNIT 4
PHASE 1 RFI/RI WORK PLAN

DECISION PROCESS FOR THE INVESTIGATION OF INDIVIDUAL, POPULATION AND ECOSYSTEM LEVEL EFFECTS AND FOR THE USE OF REFERENCE AREAS FOR COC EFFECTS

PROJ. NO.	304909	DWG. NO.	304909-B41	SHEET
DESIGN BY	I. HANNE	CHECKED	G. BRAND	OF
DRAWN BY	R. HYNA	APPROVED		
DATE	10/16/91	SCALE	NTS	

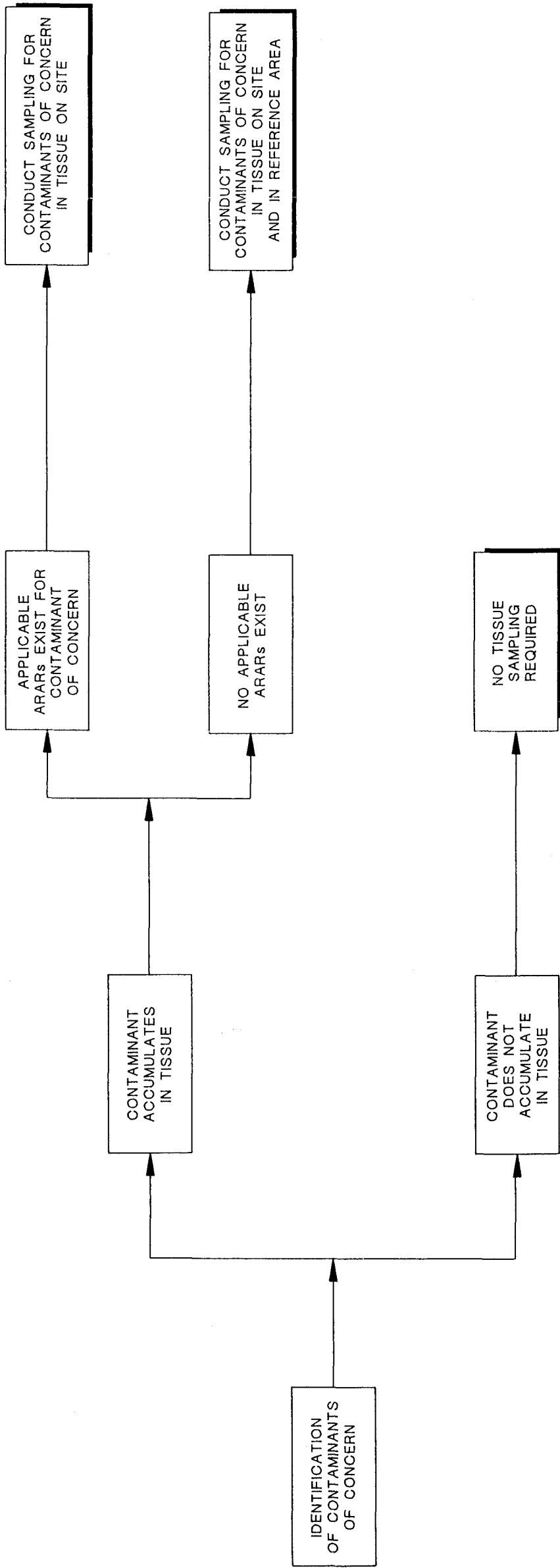


PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 9-4

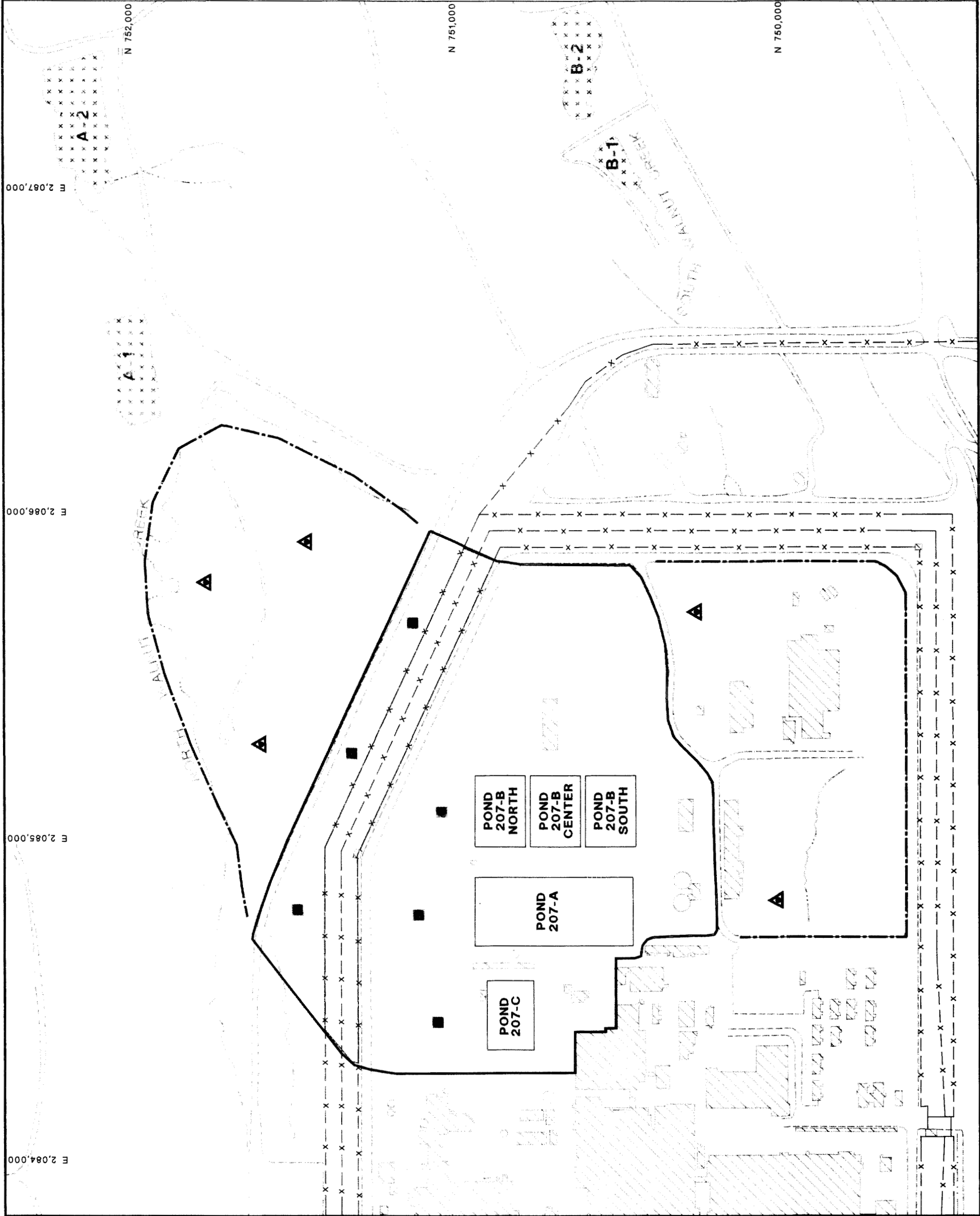
TITLE:
OPERABLE UNIT 4
PHASE I RFI/RI WORK PLAN
**DECISION PROCESS FOR
CHEMICAL SAMPLING OF
TISSUES OR EFFECTS
IN TARGET TAXA**

PROJ. NO.	304909	DWG. NO.	304909-B42	SHEET
DESIGN BY	I. HANNE	CHECKED	G. BRAND	OF
DRAWN BY	R. HYNÄ	APPROVED		
DATE	10/16/91	SCALE	NTS	



NOTE: ARARs MAY NOT BE APPLICABLE IF THEY ARE BASED ON SPECIES THAT DO NOT EXIST ON SITE (e.g., TROUT), ARE BASED ON BIOTA PATHWAYS TO HUMANS, OR THEY ARE BELOW BACKGROUND FOR THE REGION (e.g., SOME METALS).

PREPARED FOR:		U.S. DEPARTMENT OF ENERGY	
		Rocky Flats Plant	
		Golden, Colorado	
TITLE:		FIGURE 9-5	
		OPERABLE UNIT 4	
		PHASE 1 RFI/RI WORK PLAN	
DECISION PROCESS ON USE OF REFERENCE AREAS FOR CONTAMINANTS IN TISSUE			
PROJ. NO.	304909	DWG. NO.	304909-B43
DESIGN BY	I. HAYNE	CHECKED	G. BRAND
DRAWN BY	R. HYNA	APPROVED	
DATE	10/16/91	SCALE	NTS
			SHEET OF



LEGEND

- ROADS
- DRAINAGE / STREAM
- PRELIMINARY STUDY AREA
- AREA OF OVERLAP WITH OTHER OU'S
- TERRESTRIAL BIOTA SAMPLING SITE
- POTENTIAL TERRESTRIAL BIOTA SAMPLING SITE

PREPARED FOR:
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

TITLE:
**BIOTA SAMPLING LOCATIONS
FOR OU4 ENVIRONMENTAL
EVALUATION**

PROJ. NO.	304909	DWG. NO.	304909-B45	SHEET
DESIGN BY	I. HANNE	CHECKED	J. B.	OF
DRAWN BY	KRONER	APPROVED		
DATE	10-16-91	SCALE	1=300	